APR 6 1926

Printed on Thin Paper for Foreign Circulation.

"THE ENGINEER" MARCH 26, 1926.

With METALLURGICAL SUPPLEMENT.

The Engineer.

Established 1856.

Engineering Library

Registered as a Newspaper.

OFFICE FOR ADVERTISEMENTS & PUBLICATION, 33, NORFOLK ST., STRAND, LONDON, W.C. 2.

VOL. CXLI.—No. 3665] LONDON: FRIDAY EVENING, MARCH 26, 1926 [PRICE { WITH SUPPLEMENT } ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES

The Director - General, India Store Department, Branch No. 15, Belvedere-road, Lambeth, S.E. 1, invites TENDERS for :—
METALLIC FITTINGS FOR CARRIAGES.
Tenders due on the 13th April, 1926.
Tender forms obtainable from the above. 1970

Air Ministry, Directorate of Scientific Research.
JUNIOR SCIENTIFIC OFFICER REQUIRED primarily for work connected with aeronautical instruments at the Royal Aircraft Establishment. Candidates should have Honours Degree in Natural Science or Mechanical Science, and must be medically fit for flying and willing to fly. Salary £175-15-£235, plus Civil Service bonus, giving a present total starting remuneration of £278 19s. per annum, with superannuation under the Federated Superannuation System for Universities; Government contribution 10 per cent. of salary, individual contribution 5 per cent. Preference given, other things being equal, to an ex-Service man.
Application must be made on a form to be obtained from the SUPERINTENDENT, Royal Aircraft Establishment, South Farnborough, Hants, to whom it must be returned, quoting Reference No. A. 107, not later than 17th April, 1926. 1930

Applications are Invited for a VACANT POST as TECHNICAL ASSISTANT in the Naval Ordnance Department of the Admiralty.
The scale of salary is £400, rising by annual increments of £20 to £600, plus Civil Service bonus, which varies every six months and from 1st March amounts to approximately £168 on £400 and £201 on £600. A bonus allowance of £70 on basic salaries less than £500 and £105 on basic salaries of £500 and over is also payable, these amounts representing a temporary increase of 40 per cent. on the standard bonus allowances of £50 and £75.
Candidates should have an intimate knowledge of the design, manufacture and working of Fire Control Gear as installed in ships of H.M. Navy, and should have held a position of responsibility with an armament firm; such that they are fully equipped for advanced design work in this connection.
Applications should be addressed to the SECRETARY of the ADMIRALTY (C.E.), Whitehall, London, S.W. 1, not later than 9th April. Forms of application are not required. Preference will be given to ex-Service men. 1931

Assistant Engineers (Surveyors) (2) REQUIRED by the GOVERNMENT of the TANGANYIKA TERRITORY for the RAILWAY DEPARTMENT for a tour of 20 to 30 months, with possible extension. Free passages and liberal leave on full salary. Salary £600 a year plus a consolidated field allowance of £100 a year whilst discharging duties in the Territory. Candidates, not over 40 years of age, must be fully qualified Railway Engineers with a full knowledge of Barometric, Tacheometric and Location Work; must be good draughtsmen, able to produce neat large and small maps. Must have a full knowledge of instruments and be able to repair minor damages in the field, preferably should have been Railway Surveyors in unmapped tropical countries.—Apply at once by letter, giving brief details of experience and qualifications, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W. 1, quoting M/14239. 1933

Civil Engineer Required by the GOVERNMENT of the GOLD COAST for the Lay-out of the TAKORADI TOWNSHIP for a tour of not less than 12 nor more than 18 months' residential service in the first instance. Salary £480 a year for the first three years of service, then £510, rising by annual increments of £30 to £720 a year, and thence by annual increments of £40 to £920 a year. Outfit allowance of £60 on first appointment. Free quarters and liberal leave on full salary. Candidates, aged 25 to 40, must be A.M.I.C.E. or possess a degree in engineering recognised by the Institution as exempting from Parts A and B of the examination. Must be good surveyors and have had experience in Road Construction, Town Planning and Drainage Work. Candidates possessing other engineering qualifications may apply.—Application should be made at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W. 1, quoting at head of application M/14373. 1951

Civil Engineer Required by the GOVERNMENT of SIERRA LEONE for the PUBLIC WORKS DEPARTMENT for two tours of from 12 to 18 months' service with possible extension. Salary £600, rising to £720 a year by annual increments of £30. Outfit allowance of £60 on first appointment. Free passages and quarters and liberal leave on full salary. Candidates, aged 30 to 35, must have served articles with a corporate member of the Institution of Civil Engineers and have passed the examination qualifying for A.M.I.C.E. or hold equivalent professional qualifications. Must be good draughtsman, capable of designing and carrying out buildings, bridges and other engineering structures and of taking out quantities and preparing detailed plans and estimates. Must be competent to execute surveys and to lay out and construct roads and have had experience as Civil Engineers on the construction of roads, buildings and other public works.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/14274. 1925

Civil Engineer Required for the PUBLIC WORKS DEPARTMENT of TANGANYIKA TERRITORY for a tour of 20 to 30 months' service, with possible extension. Salary £480-30-£600 a year, payable in the Territory in local currency, plus a temporary allowance of 20 per cent. at present authorised up to the 31st of March, when it will be subject to review. Outfit allowance of £30 on first appointment. Free quarters and passages and liberal leave on full salary. Candidates, aged 25 to 35, preferably unmarried, must have been regularly trained as Civil Engineers, and be Corporate Members of the Institution of Civil Engineers. Must be capable of levelling, surveying, measuring up work and preparing designs of bridges, &c. Must have had at least three years' experience under a qualified Civil Engineer on the construction of Harbour Works, Drainage Works, Water Supply, or other Public Works.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W. 1, quoting M/14402. 1954

The Engineer

PRINCIPAL CONTENTS OF THIS ISSUE.
ARRANGED FOR CARD INDEXING.

Metallurgical Supplement.
THE ENGINEER, 26 - 3 - 26.

Notes on British Railways by a Continental Engineer—No. VIII.
THE ENGINEER, 26 - 3 - 26.

The High Efficiency Oil Engine.
(CHORLTON, INST. MECH.E.) THE ENGINEER, 26 - 3 - 26.

Main Line Electrification in the U.S.A.
(DAWSON & PARKER-SMITH.) THE ENGINEER, 26 - 3 - 26.

Institution of Naval Architects.
THE ENGINEER, 26 - 3 - 26.

New Double-Acting Marine Oil Engine.
THE ENGINEER, 26 - 3 - 26.

Petrol-Electric Rail Car.
THE ENGINEER, 26 - 3 - 26.

The Institute of Metals—No. III.
THE ENGINEER, 26 - 3 - 26.

Hydraulic Cargo Cranes.
THE ENGINEER, 26 - 3 - 26.

Outlook for British Shipbuilding.
THE ENGINEER, 26 - 3 - 26.

PUBLIC NOTICES

Civil Engineer Required by the GOVERNMENT of NIGERIA for the Railway (Capital Works) for a tour of 12-18 months' service with possible extension. Salary £480 a year for the first 3 years of service, then £510, rising to £720 by annual increments of £30, and thence rising to £920 a year by annual increments of £40. Free quarters and passages and liberal leave on full salary. Outfit allowance of £60 on first appointment. Candidates, aged 25-35, should have had experience as Civil Engineers on Railway Survey and Construction.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/14261. 1952

Safety in Mines Research Board.
RESEARCH APPOINTMENT.
The Safety in Mines Research Board REQUIRES an ASSISTANT to carry out research work on miners' electric lamps.
Applicants must possess a University Degree in chemistry or physics, and preference will be given to candidates with technical and practical experience in the construction of small electric lamp bulbs and secondary batteries. Ex-Service men will receive preferential consideration.
The post is a whole-time one on a scale of £250-15-350. In addition a fluctuating cost-of-living bonus is payable, making the present minimum of the scale £377 per annum. The post is tenable at Sheffield and is subject to the provisions of the Federated Superannuation System for Universities.
Forms of application, which must be returned not later than 9th April, can be obtained from the UNDER-SECRETARY FOR MINES, Establishment Branch, Mines Department, Dean Stanley-street, London, S.W. 1. 1939

Surveyor Required by the GOVERNMENT of KENYA for the PUBLIC WORKS DEPARTMENT for a tour of 20 to 30 months' service, with possible extension. Salary £300, rising to £480 a year by annual increments of £15, plus a temporary local allowance at present authorised to the 31st March, when it will be subject to review. Free quarters and passages and liberal leave on full salary. Outfit allowance of £30 on first appointment. Candidates, 23 to 30 years of age, must be capable draughtsmen and have had training with a County or Municipal Engineer and be competent to survey, align and set out roads and bridges, and must be experienced in field work.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, quoting M/14389. 1953

PUBLIC NOTICES

Test Assistant for Aircraft and Instrument Test Work at the Aeroplane and Armament Experimental Establishment, R.A.F., at Martlesham Heath, Suffolk, is REQUIRED. Candidates should have taken an Honours Degree in Mathematics or Physics and preferably should have specialised in some branch of Aerodynamics; must be medically fit for flying and willing to fly. Salary from 40s. to 80s. a week plus Civil Service bonus (giving at present a total of 60s. 11d. to 124s. 4d.), according to qualifications and experience.
Appointments will be non-pensionable. Preference given, other things being equal, to ex-service men.—Application to be made on a form to be obtained from the SECRETARY of the AIR MINISTRY, Adastral House, Kingsway, W.C. 2, quoting reference S. 2/R.461. 1879

Northampton Polytechnic Institute,
ST. JOHN-STREET, CLERKENWELL, E.C. 1.
ENGINEERING DAY COLLEGE.
An ENTRANCE EXAMINATION in connection with the ENGINEERING DAY COLLEGE of the above Polytechnic will be held on TUESDAY, APRIL 13th, 1926.
The Examination provides for admission at the commencement of the Autumn Term, 1926, and is designed to meet the convenience of intending students who desire to ascertain in advance their position in regard to admission.
Further information may be had on application to 1941 THE PRINCIPAL.

Basingstoke Corporation Electricity Department.
TENDERS are INVITED for the SUPPLY, DELIVERY and ERECTION of :—
ONE 600 B.H.P. VERTICAL CYLINDER HEAVY OIL ENGINE and DIRECT-COUPLED DYNAMO OIL ENGINE and DIRECT-COUPLED DYNAMO.
Specification, general conditions and form of Tender may be obtained from Mr. F. Swarbrick, Borough Electrical Engineer, Electricity Works, Basingstoke, on a deposit of £2, which amount will be refunded on receipt of a bona fide Tender.
Duplicate copies of specification, &c., may be had on payment of 10s. per copy, not returnable.
Sealed Tenders, marked "Tender for Generating Plant," to be delivered to the undersigned not later than Noon on 6th April, 1926.
R. H. WANKLYN,
Town Clerk.
Municipal Offices, Basingstoke,
March 12th, 1926. 1874

PUBLIC NOTICES

Bombay, Baroda and Central India Railway Company.
The Directors are prepared to receive up to Noon on Friday, 16th April, TENDERS for the SUPPLY of :—
1. LOCOMOTIVE BOILERS.
2. WHEELS and AXLES for CARRIAGES and WAGONS.
3. PARTS for CONSTRUCTING SALOONS and WAGONS.
Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of 20s. each for Nos. 1 and 2, and 10s. each for No. 3 (which will not be returned).
The Directors do not bind themselves to accept the lowest or any Tender.
S. G. S. YOUNG,
Secretary.
Offices: The White Mansion,
91, Petty France, S.W. 1.
24th March, 1926. 1975

Slough Urban District Council.
PUMPING PLANT.
The Council invite OFFERS for the INSTALLATION of PUMPING PLANT to lift 50,000 gallons of water per hour from a 30in. dia. borehole at Datchet.
Contractors may Tender for either Oil Engine or Motor-driven Pump, which is to draw water about 60ft. below surface.
Particulars can be obtained from, and Offers, endorsed "Pumping Plant," should be delivered to the undersigned by Noon on Monday, the 19th April, 1926.
ALAN BROMLY, A.M.I.C.E.,
Water Engineer,
William-street, Slough.
Slough, 15th March, 1926. 1862

TENDERS INVITED.
The County of London Electric Supply Co., Ltd.
BARKING POWER STATION EXTENSIONS, 1926.
The County of London Electric Supply Company, Ltd., are open to receive TENDERS for the SUPPLY and ERECTION of the following APPARATUS at their Barking Power Station :—
(1) SWITCHGEAR and ACCESSORIES.
(2) TRANSFORMERS.
(3) PIPING EQUIPMENT.
Specifications may be obtained by manufacturers from the offices of the Company on application to the undersigned on or after March 30th, 1926, on payment of a fee of £5 5s. for the first copy and £2 2s. for every subsequent copy.
Separate sealed Tenders, marked "Tender for Switchgear and Accessories" or "Transformers" or for "Piping Equipment," should be addressed to the undersigned and lodged at the registered offices of the Company by Noon on the 11th May, 1926.
Sums paid for any number of copies up to three will be refunded on receipt of a bona fide Tender.
The Company do not bind themselves to accept the lowest or any Tender.
F. C. McQUOWN,
Joint Manager and Secretary.
County of London Electric Supply Co., Ltd.
Moorgate-court, Moorgate-place,
London, E.C. 2. 1956

Urban District Council of Enfield.
OIL GAS ENGINE PUMPING PLANT.
The Council invite TENDERS for the PURCHASE of the following PLANT, now standing at their Sewage Disposal Works, Cuckoo Hall Farm, Lower Edmonton, N. :—
Three 50 B.H.P. Andrews Suction Gas Engines.
Three Andrews Suction Gas Plants.
Two Water Cooling Tanks, total capacity 5000 gallons.
One Ditto Ditto, 1500 ditto.
Two 3½in. and 3in. Shafting complete with Fast and Loose Pulleys, Wall Brackets, and Stop Valves.
Gas and Water Pipes and Stop Valves.
Three 9in. Gwynne Invincible Centrifugal Pumps with Fast and Loose Pulleys, Suction and Delivery Pipes and Sluice Valves, except those built into walls of floors.
Three 6in. Leather Driving Belts.
Three 8in. Ditto Ditto.
Polished Steel Guard Rails and Pillars.
Inverted U Pipe outside North End of Old Pumping Station down to first joint above ground level.
The person whose Tender is accepted will be required to do all the necessary pulling down and carriage at his own expense, and to pay the amount of his Tender before commencing the work.
The Plant may be inspected on application to Mr. E. C. Stamp, the Works Manager at the Farm.
Tenders, endorsed "Tender for Gas Plant," to be sent in to me not later than Noon on Tuesday, the 6th April next.
T. W. SCOTT,
Clerk.
Public Offices,
Enfield, Middlesex.
19th March, 1926. 1924

PUBLIC NOTICES (continued) Page 2.

SITUATIONS OPEN, Page 2.
SITUATIONS WANTED, Page 2.
AGENCIES, Page 2.
COMPANY MEETING, Page 3.
MACHINERY, &c., WANTED, Page 4.
PARTNERSHIPS, Page 2.
AUCTIONS, Page 100.
FOR SALE, Pages 4, 8 and 100.
BUSINESSES and PREMISES (For Sale, etc.), Page 3.
PATENTS, Page 4.
WORK WANTED, Page 8.

For Advertisement Rates see Page 357, Col. 1.

INDEX TO ADVERTISEMENTS Page 99.

PUBLIC NOTICES

The South Indian Railway Company, LIMITED.

The Directors are prepared to receive TENDERS for the SUPPLY of :—

1. HELICAL and VOLUTE SPRINGS.
2. HARD SOLID DRAWN COPPER TUBES.
3. INDIA RUBBER GOODS.

Specifications and forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Springs," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 9th April, 1926.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10s. for each copy of Specification No. 1, and of 5s. for each copy of Specifications Nos. 2 and 3.

Copies of the drawings may be obtained at the offices of the Company's Consulting Engineers, Messrs. Robert White and Partners, 3, Victoria-street, Westminster, S.W. 1.

W. B. REYNOLDS,
For Managing Director.

91, Petty France, S.W. 1,
24th March, 1926. 1984

West Ham Union.

The Guardians invite TENDERS for the SUPPLY and DELIVERY of TWO Direct-current ELECTRIC MOTORS, totally enclosed, shunt wound, 100 volts, 750 r.p.m., together with SLIDE RAILS, TWO STARTING PANELS consisting of D.F. Switches and Fuses and Starter and Pulley.

Motors to comply with the requirements of the B.E.S.A. Specification No. 168, 1923, and tested before leaving works and a guarantee given.

Firms tendering to specify particulars of design and construction.

Tenders must be delivered at my office by 10 a.m. on Thursday, the 8th April, 1926.

L. E. FRAQUET,
Clerk.

Board Room, Union-road,
Leytonstone, E. 11. 1955

Administrative County of LONDON.

HOUSING DEVELOPMENT SCHEMES.
APPOINTMENT OF A TEMPORARY ASSISTANT TO ADMINISTRATOR.

The London County Council invites APPLICATIONS for the POSITION of an ASSISTANT on the temporary staff of the Administrator of Housing Development Schemes. The candidate appointed will be required to act as an Assistant in the Control and Supervision of large Contracts of Housing Development Schemes and other works entered into by the Council. Candidates should have been trained either as Civil Engineers or Architects, and have had considerable experience in the Conduct of Large Construction Works. Experience as a Resident Engineer or as an Architect with outdoor experience is required, and commercial knowledge gained on the staff of a large contractor would be a qualification.

Preference will be given to candidates who served or attempted to serve with H.M. Forces.

The salary attached to the appointment will depend upon the qualifications possessed by the successful applicant, and will not exceed an inclusive rate of £1200 a year.

Forms on which application must be made can be obtained either personally or by sending a stamped and addressed foolscape envelope, marked "Assistant to the Administrator," to the Administrator of Housing Development Schemes, The Old County Hall, Spring-gardens, S.W. 1. The latest time for receiving applications is 11 a.m. on Monday, 12th April, 1926.

MONTAGU H. COX,
1914 Clerk of the London County Council.

Ashton and District Waterworks

WANTED in Engineer's Department, an ASSISTANT SURVEYOR and DRAUGHTSMAN. Commencing salary £206, rising annually by £20 to £300 per annum.

Apply, stating age, qualifications, previous experience, and enclosing copies of three recent testimonials, to WATERWORKS ENGINEER, Town Hall Chambers, Ashton-under-Lyne, before Wednesday, 31st March, 1926. 1977

County Borough of Wolverhampton.

WATER DEPARTMENT.
CHIEF ENGINEERING ASSISTANT.

APPLICATIONS are INVITED from Chartered Civil Engineers for the APPOINTMENT of CHIEF ENGINEERING ASSISTANT to the Water Engineer.

Experience in the design and construction of Pumping Works will be an advantage to the applicants.

The salary and bonus will be £460 per annum, advancing by two annual increments of £25 (salary and bonus), subject to satisfactory service, and subject to percentage deductions in accordance with the Local Government and other Officers Superannuation Act, 1922. The selected candidate will be required to pass a satisfactory medical examination.

Applications, stating age, qualifications, experience, and present salary, together with copies of three recent testimonials, must be delivered to the undersigned before 31st March, 1926, envelopes to be endorsed "Chief Engineering Assistant."

Canvassing members of the Council personally or otherwise will disqualify applicants.

F. E. WARBRECK HOWELL,
Town Clerk.

Town Hall, Wolverhampton,
16th March, 1926. 1858

Great Southern Railways.

JUNIOR DRAUGHTSMEN.

The Directors of the Great Southern Railways REQUIRE FOUR JUNIOR CIVIL ENGINEERING DRAUGHTSMEN, three for the Chief Engineer's Office, Broadstone, Dublin, and one for the District Engineer's Office, Cork. Commencing salary £150 per annum.

Applicants should not exceed 25 years of age.

Previous experience not essential in the case of an applicant who has had a training in a School of Civil Engineering.

Applications, which should state age and give full particulars of training and experience, and be accompanied by not more than two copies of recent testimonials, should be posted so as to reach the undersigned not later than 10 a.m. on 1st April next.

C. E. RILEY,
Secretary.

Kingsbridge Station, Dublin,
11th March, 1926. 1860

Hackney Union.

ENGINEER-IN-CHARGE.

The Guardians invite APPLICATIONS for the APPOINTMENT of ENGINEER-IN-CHARGE at their Institution, Hospital and Children's Homes at Homerton, E. 9.

Candidates must be thoroughly competent to supervise the Engineering Department, take charge of the Engineering Plant (Steam and Electrical), and perform certain other duties in connection with Buildings, Works of Repair, &c., at the several establishments. Further particulars of the duties will be supplied with form of application.

Salary £450 per annum, together with dinner and tea daily when on duty.

The appointment will be subject to the provisions of the Poor Law Officers' Superannuation Act, 1896, and to the National Insurance Acts, so far as applicable.

Canvassing the Guardians, either personally or otherwise, is strictly prohibited, and will disqualify a candidate.

Applications, on printed forms to be obtained at my office, must be returned not later than Wednesday, the 7th April, 1926.

FRANK R. COLES,
Clerk to the Guardians.

Clerk's Office, Hackney Union,
2, Sidney-road, Homerton, E. 9,
22nd March, 1926. 1943

PUBLIC NOTICES

New Zealand Government Railways.

APPLICATIONS are INVITED for the POSITION of ASSISTANT CHIEF MECHANICAL ENGINEER. Salary £850 per annum rising to £1000. Age limit 45. Applicants must be Associate Members or Members of the Institution of Mechanical Engineers.—Full particulars and forms of application obtainable from the HIGH COMMISSIONER FOR NEW ZEALAND, 415, Strand, London, W.C. 2, by whom completed applications will be received up to and including the 30th April, 1926. 1902

New Zealand Government Railways.

APPLICATIONS are INVITED for the POSITION of CHIEF DRAUGHTSMAN, Locomotive Branch. Salary £715 per annum. Age limit 45. Applicants must be Associate Members of the Institution of Mechanical Engineers or have passed equivalent examination.—Full particulars and forms of application obtainable from the HIGH COMMISSIONER FOR NEW ZEALAND 415, Strand, London, W.C. 2, by whom completed applications will be received up to and including the 15th April, 1926. 1901

Egyptian State Railways, Telegraphs and Telephones.

THE EGYPTIAN STATE RAILWAY ADVERTISER

A weekly publication in Arabic, English and French.

Subscription : 50 Egyptian Piastres (about 10 shillings and sixpence) yearly.

An organ of the Egyptian State Railways, Telegraphs and Telephones, containing information of interest to Contractors and Suppliers of Materials and Stores used by the Administration.

For particulars apply to PUBLICITY SECTION, Egyptian State Railways, Cairo, (Egypt). 1170

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

WANTED, a Young Energetic ENGINEER of Good appearance and address, experienced in Reinforced Concrete and Steel Work, to call upon clients and to work from London office; must be a live wire. State age, experience, and salary expected.—Address, 1979, The Engineer Office. 1979 A

WANTED, ESTIMATING and COST CLERK; must be thoroughly experienced in Card Systems and all Modern Costing and Estimating Practices.—Apply, stating age, experience, and salary required, to COWANS, SHELDON and CO., Limited, Crane Makers, Carlisle. 1957 A

WANTED for Large Works, a First-class SUPERINTENDENT STOREKEEPER. Must possess a thorough knowledge of the most up-to-date Storekeeping Methods and have held a similar post in large modern works with success.—Address, stating full experience, age, salary expected, present and past positions, in confidence, 1978, The Engineer Office. 1978 A

WANTED, MAN with Experience in Gas Fire Furnaces, to Seek Orders and Follow Up Enquiries, and to Develop the Outside Business of a Furnace Company.—Address, stating age, salary required, and particulars of experience, 1960, The Engineer Office. 1960 A

CIVIL ENGINEER WANTED, WATERWORKS and SEWER CONSTRUCTION EXPERIENCE, to SUPERINTEND WORK, WEST COAST, SOUTH AMERICA. One to three years. Fluent Spanish indispensable. Salary £100 monthly. First-class passage out and home.—Write full particulars experience, age, &c., to Box 5, c/o Judd's, 87, Gresham-street, E.C. 2. 1932 A

CONSULTING ENGINEER and MANUFACTURER has an OPENING in his London Office for a PREMIUM PUPIL. Must have a good general education, some knowledge of drawing an advantage. Would be given a thorough training with a view to a permanent post when proficient. Interview by appointment.—Address, 1986, The Engineer Office. 1986 A

REQUIRED by Manufacturers of Fuel Oil Burning Apparatus, a COMMERCIAL ENGINEER as Sales Representative and Assistant to Chief Engineer. Address, stating age, oil fuel and sales experience, and remuneration required on salary and commission basis, 1987, The Engineer Office. 1987 A

YOUNG Energetic ENGINEER, Well Educated, experienced in Furnace Design and possessing commercial ability. Good prospects for right man.—Address, stating age, qualifications, and salary expected, 1910, The Engineer Office. 1910 A

WANTED, Experienced LOCOMOTIVE DRAUGHTSMEN, including LEADING HAND. North of England.—Address, stating experience, &c., 1869, The Engineer Office. 1869 A

SITUATIONS OPEN (continued)

WANTED by a Firm of Reinforced Concrete Engineers, a competent DRAUGHTSMAN.—Write, giving full particulars as to age, experience, and salary required, to Box 2300, c/o A. W. Brown, 39, Tothill-street, London, S.W. 1975 A

WANTED, ENGINEER DRAUGHTSMAN; First-class knowledge design of Conveyors, Elevators, Structures, latest methods Coal Screening and Colliery Plants, able set out quick designs, quantities, and original schemes for general conveying problems. Accustomed latest up-to-date drawing-office methods and processing of work for foundry, machine and plating shops.—Address, 1928, The Engineer Office. 1928 A

WANTED, JUNIOR DRAUGHTSMAN, with Shop experience preferred, used to Marine Auxiliaries or Refrigeration.—Address, 1980, The Engineer Office. 1980 A

WANTED, Young DRAUGHTSMAN, with Boiler shop experience. State age, experience, salary expected.—Address, P.O. Box 4, Hyde, Cheshire. 1945 A

DRAUGHTSMAN DESIGNER, First-class, REQUIRED by Large Manufacturing Firm, with thorough knowledge of Internal Combustion Engine design and experience in design of Engines for Commercial Cars.—Address, in confidence, stating qualifications, with full particulars of career and salary required, P1735, The Engineer Office. P1735 A

DRAUGHTSMAN (Leading), to Control London Drawing-office. Must be expert in Constructional Engineering, particularly Light Steel Buildings. State age, experience, where acquired, and when free, also salary required.—Address, 1942, The Engineer Office. 1942 A

MECHANICS, FITTERS and ENGINEERS, Desiring more economical and lucrative employment, should write for particulars of my intensive course in draughtsmanship. There is an increasing demand for qualified draughtsmen and you can learn this interesting profession while you are earning. Postal or private tuition by arrangement.—PERCY PITMAN, M.I. Mech. E., 25 Victoria-street, Westminster, S.W.1. 1907 A

PATTERNMAKERS.—Permanency for Capable Men. District rate.—Apply, F. J. SMITH, 2a, Wynyatt-street, Goswell-road, E.C. 1. 1927 A

PLATER and TEMPLATE MAKER WANTED AT ONCE in Constructional Steel Work and Bridge Yard. Must be really first-class man.—Apply, stating previous employment and wages required, also send copies of testimonials, to PRING and ST. HILL, Limited, Constructional Engineers, Bedminster, Bristol. 1935 A

SITUATIONS WANTED

AMBITIOUS MAN (26) SEEKS POSITION; Office and works experience, general eng., carr., wagon and loco.; would make good assist. to works manager. Low salary until abilities proved. Who'll give me an opening?—Address, P1692, The Engineer Office. P1692 B

A. M.I. MECH. E. Exam., Keen, Energetic, Practical steam and internal combustion experience, lecturer, DESIRES SITUATION any capacity.—Address, P1743, The Engineer Office. P1743 B

CIVIL ENGINEER (30) (A.M.I.C.E.), Experience in England and the East, SEEKS PARTNERSHIP with established firm of Civil Engineers in London or the Far East.—Address, P1748, The Engineer Office. P1748 B

ENGINEER, Ex-Manager, Ex-Sub. Director, Large firms abroad, ship repairs, dry dock, lighter construction, slipway, &c., practical and technical knowledge all branches trade, harbour experience for marine survey, fluent Spanish, knowledge Portuguese and Italian, B.O.T. Certificate, splendid foreign references, understanding commercial life South American Republics, especially Argentine, DESIRES POSITION, home or abroad, as Representative or Assistant Director of Works.—Apply, PERCY J. BARTHOLOMEW, 33, Queen's-road, Portsmouth. P1682 B

ENGINEER (25), S.I. Mech. E., S. and G. Final Certificates Mech. Eng., capable of works manager's assistant or of taking control of small plant. Full works experience.—J. BROWN, 11, Andrews-road, E. 8. P1742 B

ENGINEER (28), Ex-officer, Married, Keen, Energetic, DESIRES EMPLOYMENT. Good refs. Reasonable salary; 5 yrs. coal research, coal plants (washing, briquetting, coking). Short experience D.O. and small motor parts.—Address, P1730, The Engineer Office. P1730 B

ENGINEER, M. and E., Works and Technical training, foundry experience, managerial, moulding machine design, crane erection, capable draughts man DESIRES suitable POST.—Address, P1732, The Engineer Office. P1732 B

ENGINEER, Mechanical, Electrical. DESIRES CHANGE. At present electrical superintendent, 3-wire public supply co. Seaside, country or abroad.—Address, P1731, The Engineer Office. P1731 B

ENGINEER, Young, Single, SEEKS POST, Home or abroad; 7 yrs. in gen. shop, steam, gas, oil, and Diesel eng., electrical, colliery and pumping plant exp.—Address, P1739, The Engineer Office. P1739 B

EXPERIENCED HEAVY FORGEMAN, Just Back on holiday from United States, 24 years in important shops there, DESIRES WORK in United Kingdom because of family ties.—Address, P1733, The Engineer Office. P1733 B

SITUATIONS WANTED (continued)

HIGH-GRADE DIESEL SALES ENGINEER (M.I. Mech. E.), well known and with most successful record and experience, both technical and commercial, will shortly REQUIRE responsible POSITION, preferably London.—Address, P1737, The Engineer Office. P1737 B

POST WTD. with General Engineers, London Dist., by Chief Draughtsman; energetic progressive organiser, capable controller, with wide mech. experience, sound training. The right man for you.—G., 48, Queen's-road, New Malden. P1744 B

DRAUGHTSMAN (21), with D.O. Experience of boiler house work, SEEKS SITUATION in London area. Good tech. education and shop experience.—Address, P1745, The Engineer Office. P1745 B

JUNIOR DRAUGHTSMAN SEEKS SITUATION; varied experience, good references, moderate salary.—Address, P1741, The Engineer Office. P1741 B

YOUNG MAN (21) SEEKS EMPLOYMENT as Junior Draughtsman. Five years' mixed shop and D.O. experience in mech. department at Rosyth Dockyard, 4 years dockyard school. Excellent refs. Glasgow district preferred.—Address, P1740, The Engineer Office. P1740 B

FOREMAN MILLWRIGHT, Mechanical and Electrical Engineer, with 25 years' practical and technical experience. Thorough all-round experience with every description of plant and machinery, mechanical and electrical, and power transmission. Complete workshop training, capable of undertaking all repairs. Good organiser and disciplinarian, accustomed to complete control.—Address, P1747, The Engineer Office. P1747 B

PARTNERSHIPS

IF YOU ARE SEEKING
A PARTNER or PARTNERSHIP
or wish to buy or sell a
BUSINESS or WORKS
Write:
WHEATLEY KIRK, PRICE & CO.,
46, Watling Street,
London, E.C. 4.
Established over 70 years.

A PARTNER with Capital of £500 to £1000; Must be a Motor Engineer and Draughtsman (sound American proposition). Money under own control (patents to be taken out). Liverpool district preferred.—Apply or write, B. TEAR, 59, Premier-street, Everton, Liverpool. P1729 C

DIRECTOR of Small Ironworks Co., Ltd. (very old established, busy), wishing to retire, would SELL his POSITION and INTEREST. Capital required about £500. Suit foundryman.—Address, P1734, The Engineer Office. P1734 C

PRACTICAL ENGINEER, with 20 Years' Experience refrigeration, hydraulic, marine and general engineering, WISHES POST with good firm of Consulting Engineers with view to partnership.—Address, P1736, The Engineer Office. P1736 C

EDUCATIONAL

COACHING in CIVIL ENGINEERING SUBJECTS. —To G. W. M. BOYCOTT, Assoc. M. Inst. C.E., Chandos House, Palmer-street Westminster, S.W. 1. 1881 E

CORRESPONDENCE COURSES for Inst. C.E., Inst. Mech. E., London Univ. (Matric., Inter B.Sc.), and ALL ENGINEERING EXAMINATIONS, personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Eng., London, Assoc. M. Inst. C.E., Chartered Civil Engineer, M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams., comprising hundreds of successes. Courses may commence at any time.—Apply to Mr. TREVOR W. PHILLIPS, B.Sc. (Hons.), A.M.I.C.E., &c., 9/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN-STREET, LIVERPOOL. Telephone No. 1118 Bank. Ex. E

LEARN SURVEYING and LEVELLING.—Thorough practical instruction by expert.—E. MOUL (late L.S.W. and S.P.D. Rlys.), Hollybank, Woking. P1334 E

PITMAN'S POSTAL COURSE IN ENGINEERING DRAWING.—My old-established and intensive course in Mechanical Draughting and Machine Design is of the greatest value to all those preparing for examinations, or who are employed in the daytime and are anxious to obtain a more interesting and profitable occupation. Students prepared for all Engineering examinations. The course may be started at any time.

Send for particulars and enrolment form.

PITMAN'S, 23, Victoria-street, London, S.W. 1.

AGENCIES

WANTED, AGENCIES for India by Large Engineering Firm having over half a century's connections in that country, for Machine Tools, Workshop Appliances, Cranes, Valves, Power Plant Specialities, &c. Side lines will be considered.—Address, 1939, The Engineer Office. 1939 D

WANTED by Old-established Firm in South Wales, who has good connection with collieries, works, and railways, ONE or TWO First-class AGENCIES.—Address in first instance, P1708, The Engineer Office. P1708 D

ENGINEERS, First-class Standing, Established in London 20 years, representing two well-known firms, able UNDERTAKE another good AGENCY. Marine connection second to none, also valuable connections power stations, railway, oil and export companies. Replies treated in strict confidence.—"E. 114," Deacon's, Fenchurch-avenue, E.C. 3. 1972 D

REPRESENTATION of Well-known Firm, DESIRED by Advertiser having London office. Most successful record; M.I. Mech. E., well versed in internal combustion engines, also refrigeration.—Address, P1738, The Engineer Office. P1738 D

For continuation of Small Advertisements see page 3.

WE SPECIALISE IN
PROMPT DELIVERY
AT
LOWEST PRICES
FOR
NEW
IRON & STEEL
BARS
COX & DANKS, LTD.,
168, Regent Street, LONDON, W. 1.
170/4, Attercliffe Rd., SHEFFIELD.
CRADLEY HEATH, Staffs.
Exchange Buildings, BIRMINGHAM.
3, The Parsonage, MANCHESTER.
Lyness Pier, ORKNEY.
WE ARE LARGE BUYERS AND SELLERS OF ALL GRADES OF SCRAP.

A BOOKLET ON THE
COUPLING OF MACHINES
Will be sent to any Engineer by
THE WELLMAN BIBBY CO. LTD.
96, KINGSWAY, LONDON, W.C. 2.

A Seven-Day Journal

M.W.B., New Deputy Chief Engineer.

In a note on this page in our issue of November 6th last we put on record the fact that Mr. H. F. Rutter had asked to be allowed to retire from the dual post of Deputy Chief Engineer and Distribution Engineer to the Metropolitan Water Board at the end of this month. During the past week his successor has been appointed in the person of Mr. C. F. Marsh, M. Inst. C.E., M.I. Mech. E., who for the past twenty years or so has held the position of Chief Assistant Engineer to the Board, serving, in turn, under three Chief Engineers—the late Mr. W. B. Bryan, the late Sir James Restler, and finally under Mr. H. E. Stilgoe, the present Chief Engineer. The appointment appears to us to be an excellent move on the part of the Board, for, first of all, Mr. Marsh is an engineer of wide experience and an acknowledged authority on concrete work, and, in addition, he has a knowledge of the ins and outs of the engineering works of "Water London," which cannot, we think, be exceeded—if, indeed, it be equalled—by that possessed by any other member of its staff. Altogether, with his service with the old East London Water Company prior to the formation of the Board, Mr. Marsh has had nearly twenty-seven years' intimate connection with the waterworks of the Metropolis, and the position he hes held during the past twenty years has given him exceptional opportunities of acquiring first-hand information concerning the intricacies of the numerous pumping stations, reservoirs and filters, as well as of the extensive reticulation of supply mains. Of those opportunities he has made full use, as we have often found by experience. He has every detail at his fingers' ends, and on the many occasions on which we have had the pleasure of describing works carried out by the Board he has always afforded us courteous and helpful assistance in the preparation and checking of our articles.

Threatened Engineering Lock-out.

When we went to press last week we were stil awaiting the outcome of a conference between the representatives of the Engineering Employers' Federation and of the unions involved in the unofficial strike at the printing machinery works of R. Hoe and Co., Ltd., London. It remains now to set on record that at the last moment the strikers, with all support withdrawn from them, decided to return to work "under protest" on Monday, the 22nd. In view of this decision the national lock-out notices, which were due to take effect at stopping time on Thursday, March 18th, were cancelled by the Employers' Federation. This local source of trouble having, at least for the time being, been got over, there remains the larger issue of the national demands which the engineering unions have been pressing on the employers for nearly two years. It will be recalled that one contention of the employers against granting an all-round increase of wages was that their competitors abroad enjoyed the benefit of longer hours and lower rates of pay. As an outcome of this argument, a joint deputation of the employers and the unions waited upon the Minister of Labour to discuss with him the possibility of taking steps towards securing international uniformity in the hours of labour. An effective step in that direction was taken last week when an international conference, representing Belgium, France, Germany, Great Britain and Italy, was held in London for the purpose of interpreting certain problems arising out of the Eight Hours' Day Convention, drawn up at Washington in 1919. Agreement on all outstanding points was reached on Friday, the 19th.

An Aero-engine Endurance Test.

We have received this week from the Bristol Aeroplane Company a copy of the official report issued by the Aircraft Inspection Directorate on the condition of the Bristol Jupiter engine which between January 4th and March 8th completed, under seal and without replacements or repairs of any kind, a total mileage of 25,074 miles in a series of flights covering a total period of 225 hours 54 minutes. The average fuel consumption during the test was 21·9 gallons per hour and the average oil consumption 3·95 pints per hour. On removal from the aircraft the engine without adjustment was run for five minutes at full throttle and normal speed against a Heenan and Froude brake and was found to develop 440 brake horse-power, as compared with 452 brake horse-power when similarly tested before the trials began. When the engine was stripped for examination its condition, the official report states, was found to be excellent. Only two parts, a stretched exhaust valve and a broken valve spring, were found to require replacement before the engine could be rendered completely serviceable again. The amount of wear suffered by the principal components was in no case sufficient to make replacement necessary. No wear was observed in the cylinder bore and on seven other principal dimensions measured. The piston and eight other parts were found to have worn by varying amounts ranging from 0·001in. in the bore of the big end bush down to 0·0002in. in the crank pin diameter. During the trials the engine was not nursed in any way, but on the contrary was flown hard at full throttle for long periods during very bad weather and at other times was run at 70 per cent. to 75 per cent. of full throttle. The engine is of the latest "Jupiter" pattern and is still on the Air Ministry's "secret list." As compared with the earlier pattern, it shows a reduction of frontal area of 12 per cent., a reduction in weight of 80 lb., and an increase in output at normal and maximum speed of 50 horse-power.

A Tourist Third-Class Liner.

It is a year ago since we made reference in these columns to the 17,280-ton triple-screw passenger liner Minnekahda, of the Atlantic Transport Line, which last year inaugurated a new type of third-class tourist passenger service between London and New York. This effort to provide a Trensatlantic passage at the very economical rate of £22 for the single and £40 for the round voyage has evidently been appreciated on both sides of the Atlantic, for during ten round voyages last season the Minnekahda carried no less than 6228 tourist passengers. On Friday, the 19th instant, we were invited to inspect the liner before her departure from King George V. Dock on the following day for Boulogne and New York. She has been recently reconditioned and a new boat deck has been constructed, giving very spacious promenade decks for the use of the passengers, who have the use of the whole of the amidships section of the vessel. Other alterations which we noted include the redecoration of the public rooms, new staterooms, and improved bathroom and lavatory accommodation. This work has been carried out by the W. and A. Fletcher Company, of Hoboken, New Jersey. The ship was built by Harland and Wolff and has two wing sets of reciprocating engines with a centre shaft low-pressure turbine, the machinery being designed for a speed of 17 knots. Steam is raised in twelve coal-fired boilers. Even with her new boat deck the Minnekahda has very little top hamper, which, together with her large cargo capacity, contributes to her steadiness.

The Late Mr. W. R. Cooper.

It is with deep regret that we have to record the death of Mr. W. R. Cooper, who from 1906 to 1919 was editor of our contemporary, the *Electrician*. On leaving the Royal University of Ireland in 1890, where he obtained the degree of Master of Arts, he worked for three years under Professor Ayrton at the Central Technical College, London, where he was awarded a Works' Premium which took him to the Richmond electricity undertaking and the shops of Latimer, Clark, Muirhead and Co., of Westminster. Following the liquidation of that firm, he graduated B.Sc. in Experimental Physics and Chemistry at King's College in 1895, at the end of which year he joined the staff of Mr. James Swinburne in his consulting engineering practice. He also assisted Mr. Swinburne in editing the Physical Society's Abstracts, which subsequently became Science Abstracts. In 1901 he entered into partnership with Mr. Swinburne and Mr. G. H. Baillie, and resigned the editorship of Science Abstracts. While retaining his partnership until 1909, Mr. Cooper became editor of the *Electrician* in 1906, and held that position until 1919, when he again returned to consulting work. He was the author of a valuable book on primary batteries and the editor of the *Electrician* "Primers." He also revised the late W. G. McMillan's book on "Electrometallurgy" and contributed various papers to scientific societies, including a joint paper with Mr. Swinburne on "Problems of Electric Railways." In 1902 he was awarded a Telford Premium by the Institution of Civil Engineers.

British Electrical Development Association.

A dinner of the British Electrical Development Association was held at the Hotel Cecil on Thursday, March 18th, when Mr. R. P. Sloan, chairman of the Association and of the Newcastle-on-Tyne Electric Supply Company, presided. In proposing the toast of "The British Electrical Industries," Viscount Burnham said that there was no doubt that our position as a manufacturing country depended to a considerable extent on the electrical industry. It was probably true that power was not sufficiently employed in any of the industries. There was surely no trade that derived more advantage from electric power than that of the printer and publisher, whose machinery worked intermittently with an irregular load. It was an ideal industry from which to realise all the accumulated benefits of the electric drive. The existing system of generation and distribution would have to be thought out anew and drawn to new scales. Replying to the toast, Sir John Snell alluded in detail to the electricity report recently issued. Referring to the gas industry, Sir John said it was excellently managed and was of great benefit to the community, but there were also large gas undertakings in America where the consumption of electricity per head of population greatly exceeded the consumption in this country. There was room for both gas and electricity, and competition between them was good for invention and enterprise. Doubts had been expressed as to whether the consumption of electricity per head of population would ever reach the value at present prevailing in America, but statistics showed that the output had roughly doubled every five years, and it was to be remembered that a great part of the country had no electricity supply at all. Personally he had no doubt that in a few years to come the consumption would greatly exceed 500 units per head of population per annum, and in bringing about that expansion the British Electrical Development Association would play a great part.

A High Pressure Marine Installation.

During the last few days there was on view at the Central Marine Engine Works of William Gray and Co., Ltd., West Hartlepool, a set of high-pressure quadruple-expansion marine engines with cylindrical boilers, air preheaters and auxiliaries. The machinery has been designed for a working steam pressure of 265 lb. per square inch, and it is hoped that a reduction of about 20 per cent. in the coal consumption of the ordinary cargo steamer will be gained. The machinery has been completed in the works and is ready for placing on board a 8500-ton cargo vessel. Steam will be generated in three cylindrical boilers, two 15ft. and one 14ft. in diameter, with a length of 12ft. The temperature of the combustion gases at the base of the funnel will be about 300 deg. Fah., and by means of the firm's air preheater the air will enter the furnaces at about the same temperature. A high-pressure feed heater will also be employed to deliver the feed water to the boilers at 300 deg. Fah. The cylinder diameters are 21½in., 30½in., 45in., and 66in., with a piston stroke of 48in. Balanced piston valves with steam admitted at the centre are fitted to the three smaller cylinders, whilst the low-pressure cylinder is provided with a double-ported balanced slide valve.

The French Navy.

The work of reconstituting the French navy has been somewhat delayed by the slowing down of construction by one of the preceding Governments when there was a question of carrying out a more rigid policy of economy in the public expenditure. As some of the vessels are many months behindhand, the Minister of Marine has decided to accelerate the execution of the programme so that it may be completed in the allotted time. He is therefore asking the French Parliament to sanction the immediate construction of vessels that are to follow those for which credits were voted in July of last year. So far the vessels built or being built under the programme comprise six fast cruisers, nine destroyers, twenty-two torpedo boats, thirty-two submarines, a minelayer, a seaplane carrier, and the transforming of the battleship Bearn for the transport of seaplanes. The additional vessels which it is proposed to construct during the year beginning with July next consist of a cruiser, three destroyers, four torpedo boats, a submarine cruiser, five large submarines, a submarine minelayer, a vessel for revictualling submarines and a training ship. One reason for hastening the construction is to provide work for some of the private shipyards, which are almost entirely destitute of employment. French shipbuilders are complaining of the way in which they are losing foreign orders, even when their estimates are below those of their competitors. Lower French tenders are, they say, often refused because foreign countries are showing an increasing tendency to keep the work at home.

The Electrical Industry in 1925.

At the annual luncheon of the British Electrical and Allied Manufacturers' Association, held on Thursday, March 18th, Colonel R. K. Morcom, chairman of the Council, referred, among other things, to the home demand for electrical plant and apparatus during 1925. The electrical industry, he said, did not escape from the general depression of heavy industry. There was a serious falling off of orders after the first quarter of the year, and especially in orders from collieries, iron and steel works, and textile factories. Towards the end of the year there was a slight improvement, but the net result was a fall in home orders to 15 per cent. below the 1924 level. A regrettable feature was that nearly five and a-half million pounds worth of plant and apparatus for electrical purposes was imported, representing about 7½ per cent. of the turnover. The unemployment in the industry was about 6½ per cent., and had the patriotism of those who bought abroad been enough to resist the lure of foreign dumping, the industry would have been fully employed. The fall in the home turnover was not all attributable to the general stagnation, but partly to uncertainty caused by the imminence of new electrical legislation, which caused the demands for heavy plant to fall below expectations. Including replacements, the plant sanctioned by the Electricity Commissioners represented 480,000 kilowatts. In relation to the increased consumption of electricity, the figure should have been 30 per cent. higher, whilst to make any appreciable approach to the standard of electrification in competing countries it should have been doubled.

Main Line Railway Electrification.

By Sir PHILIP DAWSON, M. Inst. C.E., &c., Consulting Engineer, and
S. PARKER SMITH, D.Sc., M.I.E.E., Professor of Electrical Engineering, Royal Technical College, Glasgow.

No. XIII.—U.S.A.: SOUTH-EASTERN STATES.*

A.—NORFOLK AND WESTERN RAILWAY.

1. Reasons for Electrification.

The Norfolk and Western Railway is primarily a coal-carrying road, operating over 3000 kiloms. of route extending from Norfolk, on the Virginian coast, to Roanoke and the Pocahontas coalfield, and finally to Columbus, Ohio, with various important branches. The electrified portion of the line is in the Pocahontas coalfield, which contains over 200 mines, their output constituting 80 per cent. of the total coal freight tonnage of the railway. With one exception, the maximum gradient outside the electrified zone is 5°/₀₀.

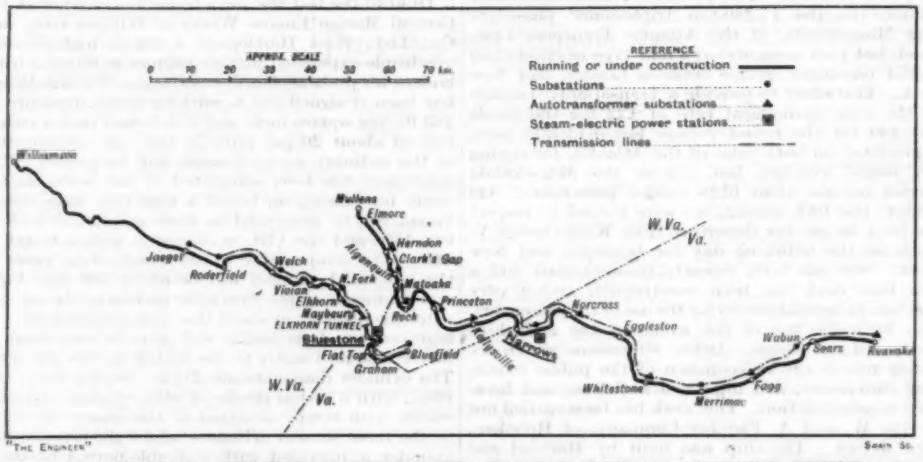


FIG. 1—NORFOLK AND WESTERN RAILWAY AND VIRGINIAN RAILROAD—ELECTRIFIED SECTIONS

A map of the electrified portion of the line is shown in Fig. 1 and a profile in Fig. 2. At present the limits of the electrified zone are at Bluefield and Jaeger. The whole route is double-tracked, with numerous central and side passing tracks, except in the Elkhorn Tunnel, 1 kilom. long, where a single line is used. The maximum gradient to eastbound (*i.e.*, loaded) trains is about 20°/₀₀, and 60 per cent. of the whole electrified zone is on curves.

The train movement consists mainly of hauling loaded coal trains through the section in an eastbound direction. Although this important eastbound movement is against the heaviest gradients, there is also an opposite coal movement down these gradients, and a very large and rapidly growing west-bound movement from the mines on the western section of the present electrified division. Periodically the line has to be cleared for the passage of four through passenger trains, eight local passenger trains, and eight time-freight trains. The handling of these latter trains through the mining section on schedule time represents one of the most important operations to be maintained.

Owing to the difficult physical features of the location, and the restricted width of road, the Elkhorn gradient division constituted a "bottle-neck" restriction on the working of the line as traffic increased, and the railway company decided in 1913 to adopt electric traction in the division.

2. Choice of System.

The study of the characteristics of the line for electrification was then undertaken. The use of a system employing a third rail was out of the question, as there is no private right of way, miners and shunters using the tracks indiscriminately. In consequence of the heavy power demands, as high a voltage as convenient was required in order to reduce the current to be collected. The probability of ultimate extensions led to the decision for single-phase alternating current at 11,000 volts and 25 cycles.

It was considered that the normal single-phase commutator motor was not sufficiently robust to stand up to the severe service, requiring numerous stops and starts on heavy gradients and curves. Especially would conditions be bad when double-traction was used—*i.e.*, when a train required a locomotive at each end—owing to the difficulty of ensuring a simultaneous start. The use of three-phase induction motors was therefore proposed, these motors having the necessary robust qualities and making the regeneration of energy (on down gradients) automatic. To enable a single-phase overhead line to be used this scheme necessitated the installation of a "phase converter" on the locomotives. Thus the so-called "split-phase" system was developed.

The first electric train was run in February, 1915. So satisfactory were the results that extensions were subsequently undertaken.

3. General Description.

The extent of the present electrification is indicated in Table I.

The original electrification extended from Bluefield to Vivian, electric operation of which commenced in February, 1915. An extension to Farms was opened in 1921, and to Jaeger in April, 1925. The electrified zone is at present being extended to Williamson, a distance of 77 kiloms. from Jaeger, making the main line route length from Bluefield to Williamson 172 kiloms.

Power is obtained from a central steam station at Bluestone, on Bluestone River, the site being decided by the necessity for feed and condensing water. This station takes charge of the load on the line between Bluefield and Jaeger, and will be supplemented by other supplies when extensions are completed. There are four 12,500-kilovolt-ampère turbo-alternator sets producing three-phase current at 11,000 volts, 25 cycles; and special 4400-volt, 60-cycle sets for signalling current. One of the 11,000-volt phases is connected to transformers, raising the pressure to 44,000 volts for distribution to the traction sub-stations. Although there is a sub-station at Bluestone, it is not fed directly from the 11,000-volt bus-bars, but through the 44,000-volt side by further transformation. This is intended to protect the generators from faults, &c., on the overhead contact line. The station has a rather small load-factor in consequence of its specialised service. The following figures are typical of a normal day:—

Total energy furnished in twenty-four hours	=	191,000 kWh.
Mean power during twenty-four hours	=	8,000 kW.
Mean power during the hour of heaviest load	=	11,000 kW.
Instantaneous maximum demand	=	20,000 kW.

The power factor is also low when the sets run at light loads. It may be of the order 0·66 to 0·7 with nine locomotives working, or 0·5 with six locomotives in service. An attempt has been made to raise the power factor by running a three-phase motor generator (frequency converter) over-excited. This motor generator is connected on the 60-cycle side to the network of the Appalachian Power Company, which operates a single hydro-electric station in the vicinity. The Norfolk and Western Company is under contract to act as a reserve steam plant for this company during times of low water, in return for which the motor generator set is run as a synchronous condenser when the Appalachian Company does not require power. The original locomotives were all equipped with induction-type phase converters. Since then a very satisfactory synchronous phase converter has been developed and the four new locomotives all have these synchronous converters. Even with these relatively few new converters the power factor conditions have been remarkably improved, and it is proposed to re-equip the old locomotives with the new converters so that no difficulty should be experienced in obtaining a high power factor.

To prevent the alternators running as motors during a regenerative period (when trains descending gradients recuperate more current than that required by those ascending), the excess energy is absorbed in rheostats operating automatically. These originally consisted of conical steel electrodes supported over a steel plate laid at the bottom of the canal feeding the station. The rheostat now consists of two sets of electrodes hung in a long wooden trough, through which water from the circulating system flows. The arrangement originally tried caused some trouble due to short-circuits. Since the new arrangement was installed the trouble has been eliminated. Relays are arranged to connect the rheostats across the 11,000-volt bus-bars in case of need.

The energy transmission to the sub-stations at 44 kilovolts consists of two single-phase lines, protected by an earth wire carried above. The transmission lines extend along the right of way from Bluefield to Welch. In addition, there is a two-circuit single-phase 88,000-volt transmission line on steel towers from Bluestone to Welch, a distance of 29 kiloms. by a cross country route. At Welch the 88,000-volt line is connected to the 44,000-volt

TABLE I.—*Route-Kilometres at Present Electrified (September, 1925).*

Line.		Route length, km.
Main line—Bluefield–Jaeger		95
Branches—Poco		4·7
Clift		9·2
Clinch Valley		1·6
Ruth to Bluestone		4·8
Wilcoe		8·4
Total route kilometres		123·7
Total track kilometres, approx.		357

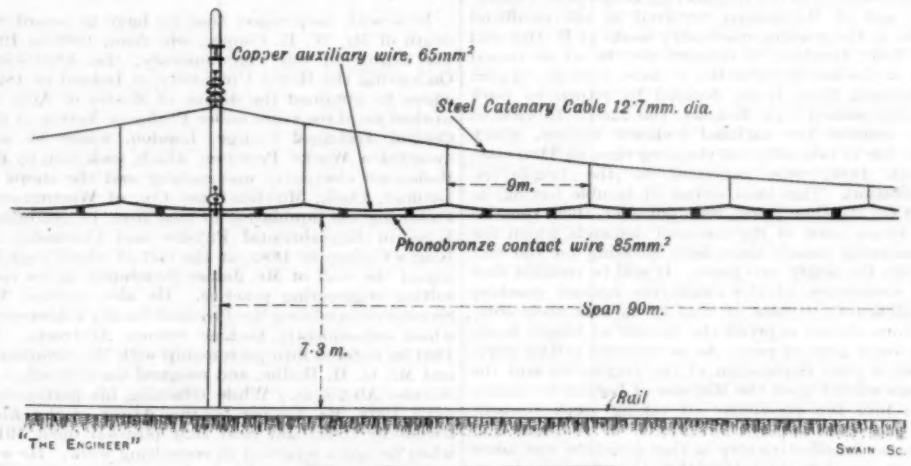


FIG. 3—CONTACT LINE ARRANGEMENT

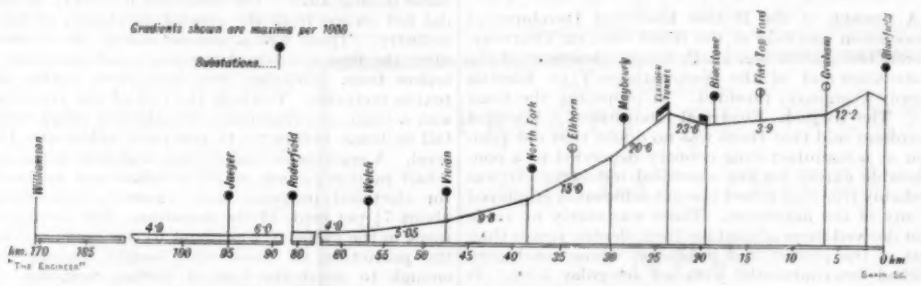


FIG. 2—PROFILE, NORFOLK AND WESTERN RAILWAY

* Nos. I., II., and III. (Switzerland) appeared June 6th, 13th, and 20th, 1924; Nos. IV. and IVA. (Scandinavia) appeared January 23rd and February 6th, 1925; Nos. V. and VI. (Germany) appeared June 5th and 12th, 1925; Nos. VII. and VIII. (Austria) appeared August 21st and 28th, 1925; Nos. IX. and X. (France) appeared October 2nd and 23rd, 1925; and Nos. XI. and XII. (U.S.A., North-Western States) appeared February 12th and 26th, 1926.

TABLE III.—*Particulars of Electrified Lines.*

Railway.	No.	Section.	GENERAL. Date opened for electric traction.	Route length, km.	Axles. Number Driving.	Axles. Number Pony.	No. of tracks.	Gauge. m.	Type.	Max. gradient °/₀₀	Weight Total. t.	Weight Adhes. t.	Weight Elect. equip. t.	Rail weight, kg./m.	Max. allowable speed, km./hr.	CONTACT LINE. Current voltage and frequency.	Length over draw-gear. m.	Wheel base. m.	Wheel dia. Driving. m.	Wheel dia. Pony. m.	Contact line.	Return	Contact line suspension	Description and spacing of supports.	No. of feeding points.	Feeding points.	Mean distance between feeding points. km.	Feeding lines.	Transmission lines	Power stations
NORFOLK AND WESTERN RLY.	1	Bluefield–Vivian, Vivian–Farm, Farm–Jaeger and branches, Jaeger–Williamson	1915 1919 1925 —	121 77			2 1 in Elkhorn Tunnel	1·435		23·6				65	50 55	Single-phase 11,000 V., 25 periods					Bronze (phono) contact wire, 85 mm² Copper auxiliary wire, 65 or 2 × 65 mm²., Steel catenary cable, 12.7 mm. dia.	Rails	3-wire simple catenary	I-section gantries, average spacing 90 m., on tangent track	8		12	None	Double 44,000 V. single-phase transmission line between Bluestone Station and sub-stations, comprising, 4 × 65 mm². copper wires	*Bluestone* (steam) Four sets 12,500 kVA., 11,000 V., 3-ph., 25 per. turbo-alternators (single-phase rating)
VIRGINIAN R.R.	2	Roanoke–Mullens	1925	215			2 between Mullens and Matonka	1·435		21·1				65 and 45	50 55	Single-phase 12,000 V. (24,000 V.), 25 periods					Bronze (phono) contact wire, 53, 65, 2 × 65, 85, or 105 mm²., as required Steel catenary cable, composite, 11 and 14 mm. copper plus copper - clad steel core	Rails and feeder	3-wire simple catenary	I-section beams and cross-catenary or bracket arms	(7 balancer stations)		31 (15)	Balancer feeder system	Double 88,000 V. single phase transmission lines on steel towers from Narrows Station to Sears and to Matoaka, thence on contact line supports to Elmore	*Narrows* (steam) Four sets, 10,000 kW., 11,000 V., 3-ph., 25 per. turbo alternators (single-phase rating)

TABLE IV.—*Electric Locomotives.*

Railway.	Series Nos.	Number	Motors.	Motor voltage.	No. of motors.	Loco. H.P. (1-hr.).	Trac. effort (1-hr.).	Speed (1-hr.).	Speed (max.).	Weight per H.P.	Drive.	Gear ratio.	Speed regulation.	Current col-lectors.	No. of trans-formers.	Cooling of trans-formers.	Braking.
Norfolk and Western Rly. (2-unit)	2500–11	12	Three-phase induction	V. 725	8	H.P. 3,200	kg. 38,000 19,000	km.p.h. 22·5 45	km.p.h.	kg.					2	Air blast	Air and regenerative
Norfolk and Western Rly. (2-unit)	2512–15	4		1150	8	4,000 4,750	49,000 28,500	22·5 45	61	92 79	Geared side-rods	4·75	Pole changing and rotor resistance	Panto-graphs	2	Oil	
Virginian R.R. (3-unit)	100–112	12			6	6,090 7,125	73,500 43,000	21·5 44	61	95 81		4·75			3	Oil	

lines through a 10,000 kilovolt-ampère single-phase auto-transformer. The transmission beyond Welch is by a twin circuit transmission line of 88,000 volts.

Sub-stations.—There are eight sub-stations, as indicated in Table II.:—

TABLE II.—*Sub-stations : Norfolk and Western Railway.*

Sub-station.	Spacing, km.	Installed capacity, kVA.
Bluefield	—	2 × 3,000 = 6,000
Bluestone	13·2	2 × 2,000 = 4,000
Maybeury	9·3	2 × 5,000 = 10,000
North Fork	10·7	2 × 3,000 = 6,000
Vivian	9·5	2 × 2,000 = 4,000
Welch	12·0	2 × 3,000 = 6,000
Roderfield	17·3	1 × 5,000 = 5,000
Jaeger	13·1	1 × 5,000 = 5,000
		14 transformers, totalling 46,000.

These sub-stations are, of course, equipped with static transformers. The stations at Bluefield, Bluestone, Maybeury and North Fork are indoor type; the other four stations are of the latest outdoor construction. There is no permanent supervision, remote control being provided from the nearest switch cabin or station. The sub-station spacing is fairly close to reduce interference with the communication circuits running parallel to the track. Twenty-three "milking" transformers of 100 kilovolt-ampères each, spaced about 2 kiloms. apart, have been used in this connection, but have been shown by experience to be unnecessary if proper sub-station spacing and balancing of impedances is provided.

Contact Line.—This is shown diagrammatically in Fig. 3. The track is almost entirely on curves, so that a construction suitable for such conditions was needed. The supports are of strong I-section beams, stiffened by two inclined ties. The contact line is such that it conforms to the track, as on curves the droppers become inclined. Transverse catenary construction is employed in stations, as that form is most suitable for several parallel tracks; in one instance eighteen tracks are so spanned. In consequence of limited space, the construction of the overhead line in the Elkhorn Tunnel had to be modified. In all cases there are two 44,000-volt type insulators between the contact line and earth, so that few breakdowns have occurred, in spite of the presence of steam traction. Maintenance is centralised at Bluestone. General data of the electrification are given in Table III.

Locomotives.—There are two classes of locomotives. The first and older type consists of twelve two-unit engines Fig. 4, Nos. 2500-11. Each unit, or half locomotive, consists of two trucks, each carrying a pair of motors. The trucks are articulated, and the two locomotive units are so connected that no stress comes on the cabs. These eight-motor two-unit locomotives complete weigh 274 tons. The drive is non-elastic; pairs of motors drive on to a common jack-axle by means of pinions and gear wheels, the transmission between driving and jack-axles being by short horizontal coupling-rods. The motors, which are of the three-phase induction type, are fed from the 11,000-volt, 25-cycle, single-phase contact line, through a transformer stepping down to 750 volts. The secondary winding of this transformer is connected to a phase converter of like frequency, and thence to the motor terminals. The phase converter weighs about 8 tons. It is constructed like a two-phase induction motor with squirrel-cage rotor, the stator carrying two windings mutually displaced by 90 deg. electrically. One winding acts as a motoring winding, the other as a generating winding. The converter is reversible, i.e., it may be employed for returning single-phase energy to the line when the traction motors are regenerating. The phases are not exactly balanced, and the power factor is low.

The motors (W – 450 – A) have wound rotors and slip rings, the stators being wound for eight or for four poles, corresponding to speeds of 22·5 and 45 kilometres per hour. The motors are connected permanently in parallel, as cascade connection would lead to switching complications not warranted by the speed control requirements. Speed control is obtained by the interconnection of a liquid rheostat with the rotors. A large Sirocco fan is installed at one end of the phase converter for ventilating that machine, the traction motors, the transformer, and the cooling heads of the liquid rheostat. The control is electro-pneumatic, the contactors being provided separately for each pair of motors. There is one reverser per unit of four motors. The sequence of operations is as follows:—

"*Speed Lever*" controlling the pole-changer connections—

(1) Off.

(2) Four motors—one truck of each locomotive unit—in circuit with eight-pole connection.

(3) Eight motors in circuit with eight-pole connection (22·5 kiloms. per hour).

(4) Four motors with eight-pole and four with four-pole connection.

(5) All eight motors, in parallel, with four-pole connection (45 kiloms. per hour).

"*Accelerating Lever*" controlling the liquid rheostats—

(1) Off.

(2) "Lower," to lower the level of the soda solu-

tion and increase the resistance of the eight rheostats.

(3) "Hold," to maintain constant resistance.

(4) "Raise," to raise the soda solution and reduce the resistance; the motor slip rings are eventually short circuited.

There is also a reversing lever.

The four new locomotives, now completed, comprise each two identical units, having a 1 BB 1 axle arrangement, and a spring geared drive. One jack shaft at each end of the unit is geared to a single motor and is connected to the driving wheels by coupling-rods. All the driving axles are on one rigid frame—Fig. 4, Nos. 2512-15 (N. and W.).

Each unit weighs 187 tons and will develop a continuous tractive effort of 20,000 kilos. at 22·5 kiloms. per hour and 12,000 kilos. at 45 kiloms. per hour,

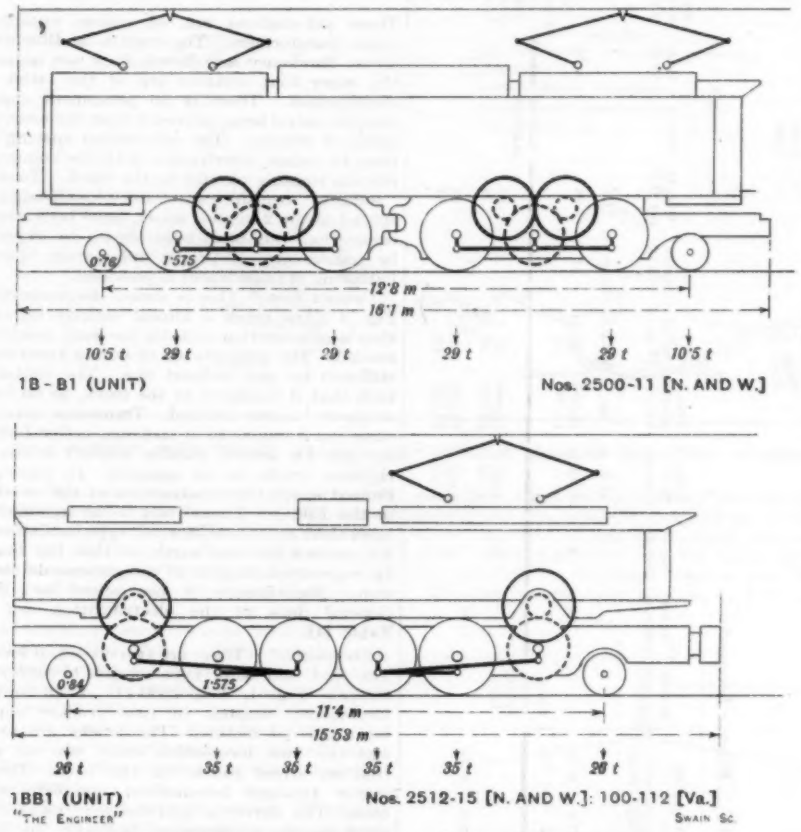


FIG. 4—ELECTRIC LOCOMOTIVES, NORFOLK AND WESTERN RAILWAY

with a maximum of 42,000 kilos. with 31 per cent. adhesion. The split-phase system is again used, while the main motors are of the three-phase induction type with wound rotors, controlled by liquid rheostats in the secondary circuits, and by pole-changing. The available data of these two locomotive types are given in Table IV., and the drives are shown diagrammatically in Fig. 4. The two outstanding electrical modifications in the new locomotives are, first, that the transformers have oil circulation cooled by radiator, and, secondly, that the phase converter is of the synchronous type, allowing of power-factor correction up to unity.

4. RESULTS OF ELECTRIFICATION.

(*a*) *General.*—The electrification, as far as increased line capacity is concerned, has been successful, and this was accomplished with the original park of twelve locomotives.

The increased line capacity is partly a result of the greater speed of trains. The characteristics of the induction motor enable a constant speed—usually 22·5 kiloms. per hour—to be maintained, as compared with 6-14 kiloms. per hour with steam locomotives. This has the further effect of increasing train-kilometres.

It is to be noted that although the rated tractive capacity of the "Mallet" engines previously used was as great as that of the electric locomotives, yet it required two road "Mallets" and one pusher "Mallet" to move a 3250-ton train over the Elkhorn gradient, while one road electric locomotive and one pusher electric locomotive were used for the same service; so that even with the old electric locomotives the increase in capacity was due, not only to increased speed, but also to higher tractive effort. With two of the new locomotives a train of 4200 tons can be taken over the gradient. The usual method, however, now is to use one of the old type as road engine with a new one as pusher, taking a 3725-ton train over the hill.

(*b*) *Energy Consumption.*—Unfortunately, the annual reports of the N. and W. Railway do not give the ton-kilometres of the electric locomotives but only the total energy consumption, *e.g.*—

In 1916	50,410,552 kWh.
1917	56,607,054 kWh.
1918	74,325,992 kWh.

(*c*) *Electric Locomotive Maintenance.*—Table V. shows the maintenance costs of electric locomotives for the years 1916 to 1922 inclusive. It should be noted that these maintenance costs include large items for reconstruction of a semi-temporary nature, in view of the various difficulties experienced. The experience gained assures low maintenance costs on subsequent locomotives of this type.

The design of the electric locomotives—without elastic drive—has led to a certain number of failures, necessitating alterations from time to time. The reasons for the damage lay in the arrangement of the motors and jack shafts on the frames. The motors have a high speed, and the jack shaft gear is small, the result being the production of shocks due to the inertia of the motors and the inelasticity of the transmission. The effects of this were first seen in the bending of the driving wheel crank pins, which were replaced with larger pins. Later, the lower bolster of the jack-axle and the fixing bolts of the stirrup were broken. They were replaced with stronger parts. The vibrations, however, continued, and resulted in the fracture of the side frames of the trucks. Various methods of repair were attempted and strengthening p ates fitted. The side frames were finally re-designed as a whole, and made in cast steel.

The traction motors are robust and need little maintenance. The phase-converters, however, have given some trouble brought about by vibration of the rotor bars. It is expected that slip-ring rotors will eventually be used.

TABLE V.—*Maintenance Costs of Electric Locomotives: Norfolk and Western Railway.*

	1916.	1917.	1918.	1919.	1920.	1921.	1922.
Number of locomotives	12	12	12	12	12	12	12
Average weight of locomotives, tons	245	245	245	245	274*	274	274
Average weight on drivers, tons	205	205	205	205	232*	232	232
Total maintenance cost, dollars	107,257	166,249	225,347	531,222	708,300	456,230	276,612
Total locomotive-kilometres	551,000	610,000	770,000	525,000	643,000	524,000	587,000
Maintenance cost, cents per loco.-kilom.	19.5	27.3	29.3	101.1*	110.6	87.2	47.1
Maintenance cost referred to 100 tons on drivers	9.5	13.3	14.3	49.1	47.4	37.6	20.3

* Increase owing to reconstruction.

(*d*) *Interference with Communication Circuits.*—To reduce the disturbing pressures induced in the communication circuits by the traction currents, the substation spacing has been kept fairly small—an average of 12 kiloms. Formerly, as already indicated, 23 "milking" transformers were connected in the line and rail circuits; their capacity was 100 kilovolt-ampères, with 2½ min. overload capacity of 400 kilovolt-ampères. The spacing was about 2 kiloms. Subsequent experience has shown these transformers to be unnecessary.

B.—THE VIRGINIAN RAILROAD.

1.—REASONS FOR ELECTRIFICATION.

The decision of the Va. Railroad in 1923 to electrify an extensive division of its route in the Alleghany Mountain belt has led to a renewed interest in electric train haulage on lines with the heaviest train-weights. With its present steam equipment the Virginian Railroad is moving 7 million tons of bituminous coal per annum from the mines on the Western slopes of the Alleghanys to tide-water at Sewalls Point, Virginia coast. Additional capacity—up to 12·5 million tons per annum—is required, and this is unobtainable with steam operation, because the limit in the power of the steam locomotive has been realised, heavier trains cannot be hauled, and the track capacity has been reached. After a thorough study the mountain gradient division, which constitutes the "bottle-neck" of the road, is now electrified.

The largest steam locomotives in use on the Va. Railroad are of the articulated Mallet type, with ten driving axles and four cylinders. Three of these engines moved the 5500-ton trains over the gradients at about 11 kiloms. per hour, their combined power being not more than 7000 horse-power. The new electric locomotives furnish 12,000 horse-power at the wheel rims, enabling 6000-ton trains to be hauled up gradients of 20‰ at 22·5 kiloms. per hour. The map in Fig. 1 and the profile in Fig. 5 show the physical characteristics of the line.

The electrification embraces 370 kiloms. of track, or 215 kiloms. of route. The heavy gradient section extends from Mullens to Princetown, 56 kiloms., and 6000-ton trains will be handled by two locomotives—one leading and one banking—up the major 20‰ gradient between Elmore and Clark's Gap. At Princetown, on the eastward journey, the trains will be increased to 9000 tons, and will proceed to Roanoke over a rolling profile, including 18 kiloms. of 15‰ down gradient, with a single locomotive. The regenerative braking features of the locomotives used are of very great importance in handling such enormous tonnage trains. The westbound returning empty wagons will be assembled at Roanoke in 2800-ton trains and hauled by one locomotive. The maximum yearly tonnage for which apparatus is installed initially is 12,500,000 tons of coal or 17,500,000 gross tonnage. The system is laid out to take care of a maximum day's traffic of 60 per cent. above that of the average day. The maximum traffic will be handled by twelve electric locomotives in service. It is intended to increase the train tonnage ultimately to 12,000 tons.

The route between Mullens and Clark's Gap was recently double-tracked to relieve congestion, while the remainder is single track throughout. The line, in common with a section of the Norfolk and Western Railway, follows the New River Valley between Glenlyn and Price.

The reasons for electrification in this case are of interest. Although the railway is situated in a district where coal is plentiful and very cheap, yet the scheme is justified by the increase in ton-kilometres obtainable, the decreased maintenance of locomotive stock, and reduction in wages of locomotive crews. The study of the problem indicated that, as far as fuel consumption is concerned, the cost of fuel under steam operation for the last year was about the same as the electric power costs would be with energy at 0·75 cent per kilowatt-hour. While a saving in fuel consumption would undoubtedly be obtained, yet the losses in transmission and conversion would equalise the cost of energy as developed by the locomotives. It is the operation economies which indicate the advantages of electrification, quite apart from the necessity of its introduction from reasons of train-tonnage.

2. CHOICE OF SYSTEM.

The choice of the electrification system was, no doubt, influenced by the successful operation of the Norfolk and Western Railway. At the same time, the need for safe and simple regenerative properties was also of great weight, and this requirement indicated the same system as the first. The system chosen was therefore the "split-phase," at a pressure of 12,000 volts, 25-cycles, at the trolley.

3. GENERAL DESCRIPTION.

Power Supply.—The electric system is as follows:—A steam-operated power-house, situated at Narrows, on the New River, approximately at the middle of the electrified section, contains four 10,000-kilowatt, three-phase, 25-cycle, 11,000-volt turbo-generator sets with boiler plant equipped to burn pulverised coal.

The question of successfully handling the traction loads imposed on the power station was a serious one; the load fluctuations are quite unprecedented. Thus to start and accelerate a 6000-ton train with its 1200-ton locomotive requires about 18,000 kilowatts, at the power-house. This load comes on and off suddenly. Often only one train is in operation at a given time, and the load fluctuations are therefore severe. The use of pulverised fuel firing has enabled

such loads to be met with only a moderate drop in steam pressure.

Power from the generating station is supplied to the locomotives through transmission lines, step-down transformers and a catenary contact line. There are two single-phase 88,000-volt transmission lines connecting the generating station with seven step-down transformer stations situated at Elmore, Algonquin, Princeton, Narrows, Eggleston, Merrimac and Sears. These step-down transformers are of special type, with two windings on the secondary. One of these windings

TABLE VI.—*Sub-stations : Virginian Railroad. Transformer Stations.*

Station.	No. of transformers.	kVA rating (each transformer).
Elmore	2	3000
Algonquin	3	3000
Princeton	2	3000
Narrows	2	3750
Eggleston	2	3000
Merrimac	2	3000
Wabun (Sears)	3	3000
Balancer Stations.		
Herndon	3	5000
Rock	1	5000
Kellyville	1	5000
Norcross	2	5000
Whitestone	2	5000
Fagg	1	5000
Roanoke	2	5000

is connected to the 12,000-volt trolley-rail circuit and the other to a feeder-rail circuit with a potential of 24,000 volts. This gives a secondary transmission circuit composed of the trolley and feeder wires, which is used to supply auto-transformer balancer stations situated between the main step-down transformer stations. By designing the transformers and the trolley-feeder, trolley-rail, and feeder-rail circuits so as to secure the proper balancing of impedance, the rail currents are reduced to a minimum and the through-feed of earth current and stub-end feed effects

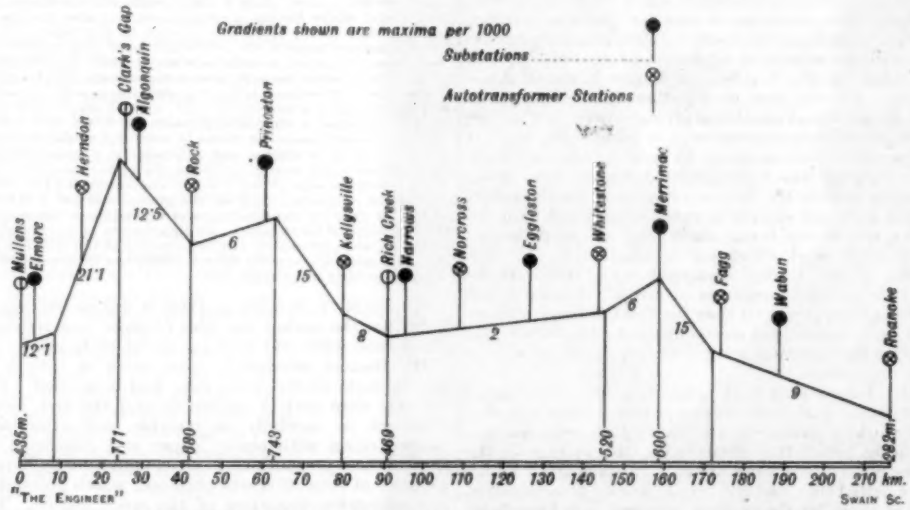


FIG. 5—VIRGINIAN RAILROAD, PROFILE OF LINE BETWEEN MULLENS AND ROANOKE

are practically eliminated. The transformer and balancer stations are enumerated in Table VI. See also section dealing with interference below. The yearly energy requirement, including shop power and central station auxiliaries, is estimated at over 117 million kilowatt-hours.

For interconnection purposes, the Narrows station is paralleled with the Norfolk and Western Railway Company's Bluestone power-house by an 88-kilovolt line about 15 kiloms. in length between Matoaka and Bluestone. The contact wire construction is of the simple inclined catenary type like that of the Norfolk and Western Railway, with a bronze contact wire and steel catenary cables, all supported on steel structures.

Locomotives.—The locomotive units embody all the experience gained by the engineers of the Westinghouse Company and of the Norfolk and Western Railway, for which similar machines are being built. Each unit, of which there are three per locomotive, weighs about 192 tons, and is of the gear and side-rod type, with jack shafts at each end—see Fig. 4, Nos. 100-112 (Va.). Each jack shaft, geared to a single motor, drives two pairs of driving axles, all four of which are mounted on one rigid wheel base. These three locomotive units develop on 1-hour rating a tractive effort of 73,500 kg. at 21·5 kiloms. per hour, and 43,000 kg. at 44 kiloms. per hour. The maximum starting effort naturally depends on the adhesion, and with a 25 per cent. coefficient it is 105,000 kg.

The main details of these locomotives are given in Table IV.

The locomotives receive current at 12,000 volts from the trolley wire; this high voltage energy is transformed down to a low pressure and feeds synchronous phase converters, which supply three-phase current to the main induction motors. The latter have slip-ring rotors, controlled by pole-changing and by the use of liquid rheostats in the rotor circuits. The rugged construction of the induction motor lends itself to reliability of operation in this very heavy service.

The 1-hour rating of a locomotive—three units—is 6090 and 7125 horse-power at 21·5 and 44 kiloms. per hour respectively.

Interference with Communication Circuits.—The distribution system adopted for the Virginian Railroad possesses certain special features which were included in it for the purpose of minimising the inductive interference. This system requires special step-down transformers, which have the mid-point of the low tension winding earthed to the rail, and the two ends of the winding connected respectively to the overhead contact line and to a balancing feeder wire. Balancing auto-transformers arranged midway between the main transformers, are connected between the feeder and contact wires, and also have the mid-point of their windings solidly earthed to the rail. Both of these transformers have their trolley-rail winding arranged for series-parallel connection, so that the trolley voltage may be increased from 12,000 to 24,000 volts when load conditions demand it. Thus there are actually three circuits in the distribution system: the 12,000 or 24,000-volt trolley-rail circuit, the 24,000-volt feeder-rail circuit, and the 36,000 or 48,000-volt trolley-feeder circuit.

On alternating current single-phase electrification, the principal inductive effects that arise are due to electromagnetic effects of the current which flows in the aerial conductors and returns in the earth, which return is in parallel with the rails. The generally favourable conditions for minimising inductive effects in closely parallel circuits are as follows:—

(*a*) For a load at any point between two transformer stations, the ampère-kiloms. of return current, that is, the product of the current and distance on either side of the load, should be approximately equal and opposite in sign.

(*b*) For a load at a transformer station, the current in the earth between stations should be a minimum.

(*c*) For a load at any point on the system, the through return feed in the earth should be a minimum.

For a load between transformer stations all the current must necessarily flow out over the contact wire and return through the earth and rails to the adjacent transformers. Also, it is obvious that the proportion of this current being supplied by the two stations will be determined by the relative impedances of the two paths. Therefore, in order to fulfil condition (*a*), namely, that the ampère-kiloms. on either side of the load be approximately equal and opposite, it is necessary to combine the transformer and circuit impedances, and to balance the impedances so as to obtain the desired current division.

For a load at a transformer station, it is necessary that the transformer impedance be low, and that the impedances between the three windings of the transformer be so proportioned as to secure a balance between the currents flowing in the trolley rail and feeder-rail circuits. The Virginian transformers were designed to meet these special impedance conditions.

The great reduction of earth current is a characteristic of the three-wire system, provided the transformers are of proper design. As has been pointed out, the trolley-rail circuit operates at a potential of 12,000 or 24,000 volts, and the trolley-feeder circuit at 36,000 or 48,000 volts. Therefore, for through feed a high voltage, low impedance path is available and the greater part of the power will be supplied over that circuit, rather than over the low voltage, high impedance trolley-rail circuit. In other words, a load between any two transformer stations will be fed over the trolley-rail circuit from these stations to the point of load, but beyond the adjacent transformers the trolley-feeder circuit will carry by far the greater part of the load, with a consequent reduction in the earth current. This also results in an improvement of the load factor of the more distant transformer stations. Similarly, a load at any sub-station will be fed by the transformer at that station and by the trolley-feeder circuits from the adjacent stations.

The type of system on the Virginian is one that is especially favourable for reducing the inductive effects on through circuits. In fact, the voltages induced in the through circuits will usually be very much lower than in a short section, between a load point and a step-down station.

The interference produced by electric induction may or may not be reduced by the presence of the feeder balancer wire, depending upon the relative position of the communication circuit with respect to the trolley and feeder wires. The static fields set up by the two conductors are of opposite polarity, and will have a neutralising effect upon each other, but in some cases the neutralisation may be more complete with 12,000-volt trolley and 24,000-volt feeder than with equal potentials on both conductors.

The Institute of Metals.

No. III.*

AT the morning session on Thursday, March 11th, one of the papers taken was by Mr. A. J. Murphy. It was on "The Constitution of the Alloys of Silver and Tin."

SILVER AND TIN ALLOYS.

In connection with an investigation of dental amalgams the constitution of the alloys of silver and tin has been determined from the freezing point down to ordinary temperatures. Based mainly on the results of heating and cooling curves and microscopic examination of heat-treated specimens, an equilibrium diagram has been constructed.† The compound Ag_3Sn, which is the fundamental constituent in the filings used for amalgamation in dental fillings, has been examined in further detail by means of determinations of electrical resistance at different temperatures, thermal expansion, and X-ray examination. The diagram now presented differs from that hitherto accepted in showing a new phase β in a range of alloys formerly believed to consist entirely of an α solid solution, and also in excluding a polymorphic transformation at 232 deg. Cent., which was said to occur in the compound Ag_3Sn. Evidence has been obtained for a transformation at 60 deg. Cent. in this compound, but the nature of the change is not clear. The lines of the X-ray spectrogram obtained from filings, both aged and unaged, from an annealed ingot corresponding in composition to the compound Ag_3Sn, are accounted for by a close-packed hexagonal structure of side $2{\cdot}98 \times 10^{-9}$ cm. and axial ratio 1·61. Experiments with pure tin and alloys of tin containing silver have shown that the presence of 0·2 per cent. of silver prevents the transformation from white to grey tin, even when in contact with grey tin.

Dr. Hanson, who commented on the magnitude of the work undertaken, said that he had only one point to raise. In connection with the compound Ag_3Sn. That compound would dissolve a small amount of silver, but showed no solubility for tin. Could the author fix any definite limits for the solubility of the constituent metals, as the information would be of value to research workers and assist them in reaching conclusions which were of great importance on the general question dealt with in the paper?

Dr. Rosenhain expressed satisfaction that the dental professional association, by which funds for the work had been provided, should not only have shown great interest in the research, but have allowed the free publication of the results.

Dr. F. Johnson regarded the contribution as a good example of academic research which might find important practical application. It was interesting to note the remarkable similarity between silver and tin and the copper-zinc alloys in some notable characteristics.

Professor C. H. Desch said that the work done confirmed the accuracy of the liquidus determinations of Haycock and Neville. Had subsequent work been carried out with the same care, text-books would not have been cumbered with inaccurate diagrams. With regard to the transformation of Ag_3Sn, it was of interest to speculate whether the change which occurred with great reluctance in the binary system might be accelerated by the addition of a third element. With regard to the transformation of tin at 18 deg. Cent., it was remarkable that this change should be suppressed entirely by the presence of a small quantity of foreign metal.

Mr. Murphy, in answer to the questions put, said that with regard to the solubility range of the compound Ag_3Sn, the point corresponded to 26·25 per cent. of tin. Alloys containing 26 per cent. might be made homogeneous by annealing, but alloys containing 27 per cent. of tin did not respond to the annealing process in that way. The true solubility figure of the gamma constituent was ·9 per cent. A point had been raised concerning the transformation of tin at low temperatures, and he agreed that a very small quantity of silver would exhibit that transformation. Some experiments on the lines suggested by Professor Desch were now in hand.

The last paper taken at the morning session of this day was by Mr. W. Hume-Rothery, on "Researches on the Nature, Properties and Conditions of Formation of Intermetallic Compounds with Special Reference to Certain Compounds of Tin, Parts I.–V." .

INTERMETALLIC COMPOUNDS.

Part I.—The theoretical proof of the Phase Rule is discussed. The Phase Rule really involves volume concentrations, but is commonly used for weight composition equilibrium diagrams. This is generally justifiable, but whenever volume changes occur unaccompanied by weight changes, the Phase Rule in its usual sense will not apply to the weight composition diagram. The proof of the Phase Rule also involves assumptions regarding the

* No. II. appeared March 19th.

† [Not reproduced.—ED. THE E.]

nature of the equilibrium between phases, which are not justified in the case of a solid crystalline compound of the components. When such a compound is formed the variability of the system is greater than the Phase Rule indicates.

Part II.—In contrast to other compounds, intermetallic compounds conduct electricity. They are formed in such a way that some only of the available valency electrons are bound into stable groupings, others being more loosely held. This conception accounts completely for their irregular valency relations. A true binary intermetallic compound will very rarely give rise to the substitutional type of solid solution, but the interstitial type is possible, although it will usually be limited in extent.

Part III.—A true compound is not present in the β solid solutions of copper, silver, and gold alloys, but these phases approximate to the compositions Cu_3Sn, Cu_3 (or Ag_3) Al, and Cu (or Ag, or Au) Zn. In all of these there is a ratio of 3 valency electrons to 2 atoms, and the phases are regarded as space lattices of electrons and atoms with a fundamental ratio of 3 : 2, but with no compound molecule in the liquid state. This conception accounts for the electrical properties of these compounds, and agrees with Lindemann's theory of the metallic state. The position of electrons in metallic crystals is discussed.

Part IV.—The freezing point diagram of the system calcium-tin is determined. Three compounds are formed, viz.:—$CaSn_3$ max. on f. pt. curve at 627 deg. Cent.; ($d_0 = 6{\cdot}01$); CaSn (break in liquidus curve at 987 deg. Cent.; $d_0 = 4{\cdot}17$); and Ca_2Sn (max. on liquidus at 1122 deg. Cent.; $d_0 = 3{\cdot}47$). No solid solutions are present. The properties of the compounds are examined, and it is shown that a natural crystal face is oxidised more slowly than a ground or polished section.

Part V.—The freezing point diagram of the system magnesium-tin is determined. A very slight range of liquid immiscibility probably exists at the tin end of the diagram. The single compound is Mg_4Sn_3 and not Mg_2Sn. It melts at 778 deg. Cent. and is blue black with octahedral cleavage. The compound Na_4Sn is also blue black with octahedral cleavage. It undergoes a remarkable reaction with water, the compound being completely decomposed, but retaining its orginal form, the whole mass being honeycombed with minute cracks parallel to the octahedral cleavages of the original crystal.

Professor C. H. Desch said that the contribution was important and full of suggestions. He had felt for some time past that work on the lines followed by Mr. Hume Rothery was very necessary. There was a tendency to use the phase rule in a loose way, and the author had pointed to the need of going back to the fundamental treatment of the rule by Gibbs. There was no doubt that the ordinary interpretation of the phase rule involved fallacies. The paper represented the first attempt to clear up the mystery of the constitution of the intermetallic compounds.

Dr. Hanson argued that much more evidence than that submitted was necessary before it could be accepted that solubility was not a characteristic of intermetallic compounds. It was not inconceivable that solid solutions could be formed by the substitution of atoms, and it could be determined by experiment. He hoped the author would not publish any more papers of the character of that now submitted until he had carried out more experiments. Theory should not be permitted to run so far ahead of practice.

Dr. Rosenhain regarded the contribution of the author as containing original ideas on fundamental matters. It would have been preferable, however, to have had the discussion in the presence of physicists who had studied the subject of electrical conductivity. In a recent discussion at Brussels certain ideas were brought forward in connection with conductivity which were at variance with Mr. Hume-Rothery's conclusions. The existence of a lattice of the kind he suggested was regarded as highly improbable. It would be surprising to find any intermetallic compound which was either a bad conductor or a non-conductor. Good conductivity was a question of regularity of the space lattice which was found in the intermetallic compound, and it was not so perfect in the solid solution. The arrangement of atoms and electrons could be shown by X-ray work.

At the afternoon session the first paper considered was one by Messrs. H. J. Tapsell and J. Bradley, on "The Mechanical Properties of an Alloy of Nickel and Copper, with Special Reference to 'Creep.'"

MECHANICAL PROPERTIES OF A NICKEL-COPPER ALLOY.

The paper deals with the results of some mechanical tests carried out on a synthetic alloy of nickel and copper (approximately 70 : 30), containing 2·35 per cent. of manganese, at a range of temperatures between air temperature and 700 deg. Cent. to 800 deg. Cent. The methods of test and the apparatus used are identical with those described in a paper by the authors, published in *Engineering*,* on the mechanical properties of a nickel-chromium alloy. The tests herein described consist of the following:—Ordinary tensile, torsion, impact, impact hardness, fatigue under reversed stresses, and "creep." Special attention is given to the study of the "creep" of the nickel-copper alloy, and determinations of the limiting creep stresses have been made between the temperatures 400 deg. Cent. and 700 deg. Cent. The paper indicates the large difference existing between the apparent ultimate strength, as determined by tests made at the ordinary rate of loading, and the safe strength, or limiting creep stress, obtained from tests made under constant loading conditions over long periods. Some comparisons of the results obtained in the ordinary tensile tests and the creep tests on the nickel-copper alloy, and the results of other experiments on Monel metal and other alloys, are given at the conclusion of the paper. The tests described form part of an investigation of the mechanical properties at high temperatures of several ferrous and non-ferrous materials, and the results of the tests on the nickel-copper alloy have been given in this paper mainly for the purpose of showing that such a synthetic alloy of nickel and copper can be made, which will give a satisfactory performance at high temperatures.

Mr. Gough said that it was suggested that at high temperature the material of the metals behaved as a viscous fluid. He had not much experience of high temperature work, but dealing with single capitals it had been shown that they deformed by means of shear on crystallographic planes. It had been possible to show that the rate of hardening was greater than that at which shear took place, and at high temperatures it was assumed that the resistance to shear would be diminished but that the hardening effect would be absent. It would be interesting if the authors were able to state whether the flow observed in these experiments was of a crystal nature or was of an amorphous character.

Dr. Hanson asked for information as to elongation under the creep test and the nature of the fracture.

Mr. Kayser regarded the paper as merely useful if one desired to pass the time. There was, of course, a demand for a metallic structure which would persist at high temperatures, but there was no metal which at 1000 deg. Cent. had any useful tensile strength. That was clearly shown by the behaviour of nickel-chromium alloys, and it was a sheer waste of time driving more nails into that coffin. He would seriously suggest that the Non-ferrous Metals Research Association should concentrate on work designed to bring about an improvement in non-ferrous alloys. Unfortunately the chief constituent in many of the alloys dealt with in the paper was nickel, and although he might be running against powerful forces, he would point out that nickel was controlled by a strong corporation, which advocated the use of exceedingly pure nickel. It was by reason of the excessive purity of the nickel content that many of the alloys failed, and there could be no doubt that the introduction of traces of other metals improved the tensile properties of the material at high temperatures. If research workers would concentrate their energies on the discovery of an alloy which possessed the necessary strength at high temperatures, manufacturers would gladly foot the bill, but for work of the kind described in the paper under discussion they had no use.

Dr. Rosenhain, in reply to Mr. Kayser's criticism, pointed out that the work described in the paper was done some time ago, but had only just been released for publication. It formed a necessary part of the research into the behaviour of metals at high temperatures. If manufacturers knew more about this subject than scientists it was for them to produce metals possessing the desired characteristics. Speaking with knowledge of what was being done in work on behalf of the Non-ferrous Metals Research Association, he was able to say that the discovery of metals and alloys capable of giving satisfactory service at high temperatures was well in hand. He was not prepared at that moment to speak about results—the problem was exceedingly difficult,—but it was only right, after Mr. Kayser's criticisms, that members of the Institute should be made acquainted with the effort which was being made, and the considerable scale of the work which was in hand.

Mr. R. W. Bailey disagreed with the authors' view as to the phenomena of creep. Evidence had not yet been produced that the limit of creep stresses had been determined as the method adopted was not sufficiently discriminating. The time factor was of real importance.

Mr. Tapsell said that other materials than nickel and copper had been the subject of experiment, but the work described in the paper had been selected to bring before the Institute as the evidence in the cases quoted was more direct. In some steels which were tested they had got very near to a determination of the limits of the creep stress, and to a knowledge of the figure which should be aimed at in order to increase the life of the material. With regard to Mr. Kayser's remarks they were quite aware that the addition of foreign materials increased the strength of nickel and other alloys, and work on those lines had been carried out.

Then followed a paper by Dr. B. S. Evans and Mr. H. F. Richards on "The Determination of Zinc Oxide in Brass."

DETERMINATION OF ZINC OXIDE IN BRASS.

A description of a method for the determination of zinc oxide in brass based on the fact that the back reaction $Zn + H_2O = ZnO + H_2$, which occurs when an attempt is made to estimate zinc oxide by Archbutt's method for estimation of oxygen in copper (*Analyst*, 1900, 25, 253), can be suppressed by the presence of sufficient copper to combine with the zinc volatilised from the sample. The estimation is carried out in the same apparatus and in much the same manner as for determination of oxygen in copper, but that part of the furnace tube which is not occupied by the boat is packed with tightly rolled copper gauze. The copper gauze is deoxidised by prolonged heating in a current of hydrogen, the furnace is then allowed to cool the sample (a lump of about 80 grammes) introduced, the packing replaced, and after sweeping out the air with hydrogen the furnace is heated up to 980 deg. Cent. and kept at this temperature until the rate of gain in weight of the phosphorus pentoxide U tube has dropped to that of a predetermined blank. The water evolved is estimated by the gain in weight of the phosphorus pentoxide U tube after deduction of the blank. Owing to the small amount of oxide which occurs in brass, somewhat elaborate precautions have to be taken to reduce the blank to a minimum; these involve additions to the purifying train and measurement of the amount of hydrogen passed.

Professor Thomas Turner said that the subject dealt with had been of interest to those engaged in the brass trade for many years. Various attempts, some of them very satisfactory, had been made to determine the amount of oxygen present in brass, but the one described in the paper, although it could be made to give an accurate result, was not likely to be used by the ordinary analyst. It was cumbersome and required too much time to be employed in commercial work. The important fact which the author had been able to determine was that under ordinary conditions no oxide of zinc was dissolved in brass.

A paper by Professor C. O. Bannister, entitled "Note on the Corrosion of an Ancient Tin Specimen," was then considered.

CORROSION OF AN ANCIENT TIN SPECIMEN.

This note contains the results of the examination of an ancient tin sheath, the metal portion of which contained 99·98 per cent. tin. The metal was covered with a corrosion product which contained 76·82 per cent. tin and 5·1 per cent. combined water. On driving off this water by heating in air the product showed a loss of only 0·59 per cent., indicating that it had gained 4·51 per cent. oxygen. These results show that the product contained hydrated stannous oxide 43·35 per cent. and anhydrous stannic oxide 54·68 per cent. The mechanism of corrosion of metallic tin therefore comprises the formation of hydrated stannous oxide and the subsequent oxidation and dehydration of this compound to stannic oxide.

Professor C. H. Desch said that tin appeared to have a great power to resist corrosion. The specimen described was supposed to be Roman, and he had seen another specimen dating from the eighth century of a material which was originally believed to be silver, but which was discovered to be tin over brass. This was another example of the resistance of tin to corrosive action. The high degree of purity of these old specimens—99·98 per cent. tin in that described in the paper—was a remarkable tribute to the metallurgical achievements of past generations.

The concluding paper of the meeting was that by Monsieur A. M. Portevin, on "Striation Due to Working or to Corrosion in Microscopical Metallography: A Contribution to the Study of the Mode of Action of Etching Reagents."

STRIATION DUE TO WORKING OR CORROSION.

There is no phenomenon, however minute or secondary it may appear, which cannot furnish material for interesting study if trouble is taken to examine carefully its mode of occurrence and its appearance. There is, for example, in microscopical metallography the appearance after etching of certain striations produced by the polishing of metals and alloys. This is a well-known fact and a source of great annoyance to all who seek to obtain perfect pictures of the structure free from these scratches; from this point of view they are but nuisances which are, if possible, avoided by suitable methods. But this annoyance may incidentally become the starting point for suggestive observations if a closer study is made, particularly in the case of metals and alloys having a crystallisation coarse enough to permit a close survey of the phenomenon on individual grains; for this purpose samples are used which have been very slowly cooled from the liquid, so as to have very well-developed crystal grains; this is what has been done in the case of examples given in this paper. In addition to this it is advisable to work on metals and alloys having a low elastic limit, such as copper and solid solutions of brass or aluminium-bronzes which are very rich in copper, in which cases the effects of work due to the polishing scratches are more intense and noticeable to a greater depth. In a previous paper on etching figures, the author has shown that these constitute one of the decisive characteristics for determining the crystalline state of the grains, and are a definite means for showing the differences of crystalline orientation in these elements of the structure. All disturbances of the crystalline structure, and particularly any deformation of the lattice, must therefore affect the etching figures, which can be developed by suitably etching the surface.

Colonel N. T. Belaiew said that it was interesting to note that the author was able to show how striation was linked with cold working of the material.

Dr. Hanson referred to some work on fatigue in which single crystal test pieces had been used. The crystals were perfect specimens and the test pieces were cut as carefully as possible, and afterwards rubbed down with emery paper and polished. In spite of these precautions, in an examination by X-rays a degree of refraction was obtained, which pointed to a considerable distortion of the space lattice. The strain had to be removed, and that was done by treatment with 50 per cent. caustic soda solution for six hours, and subsequent polishing. Dr. Hoyt had had a similar experience, and it was necessary to emphasise the need for taking the greatest care to avoid strain effects when conducting work of that kind.

The proceedings terminated with a vote of thanks to the Institution of Mechanical Engineers for giving facilities at their headquarters for holding the meeting.

NEW ARTICLES OF ASSOCIATION.

An extraordinary meeting of the members of the Institute was held on March 11th for the purpose of obtaining the assent of the members to new regulations to form articles of association in substitution for those under which the Institute is now governed.

The necessary formal resolution was adopted, and will be submitted for confirmation to a further extraordinary general meeting which will be held on March 31st.

In the course of a paper on "Rock and Air Temperatures in Deep Level Mines," read before the Chemical, Metallurgical and Mining Society of South Africa, by Messrs. M. O. Tillard and E. C. Ranson, the authors suggested that conditions in the deep level workings of the Rand were reaching the limit of physical endurance. Thus "on the Village Deep," they said, "we are gradually approaching a point when ventilation or movement of air will be of little avail in cooling the body; this will happen when a practically saturated atmosphere, such as we have in these mines, reaches 97·5 deg. Fah. or body temperature. When this point is reached it becomes impossible to perform manual work, and it will thus be imperative to introduce some other agents to enable us to carry on." Among the agencies so far explored are ice and chilled water. The ice is placed upon trays at the face of each development drive, in the delivery end of the 15in. ventilation pipes, and in the winzes chilled water is sprayed into the warm air which passes in from the development areas. The results are said to be promising, and will doubtless form the basis of a further development in the use of cooling materials or apparatus.

* *Engineering*, CXX., 614, 648, 746.

Obituary.

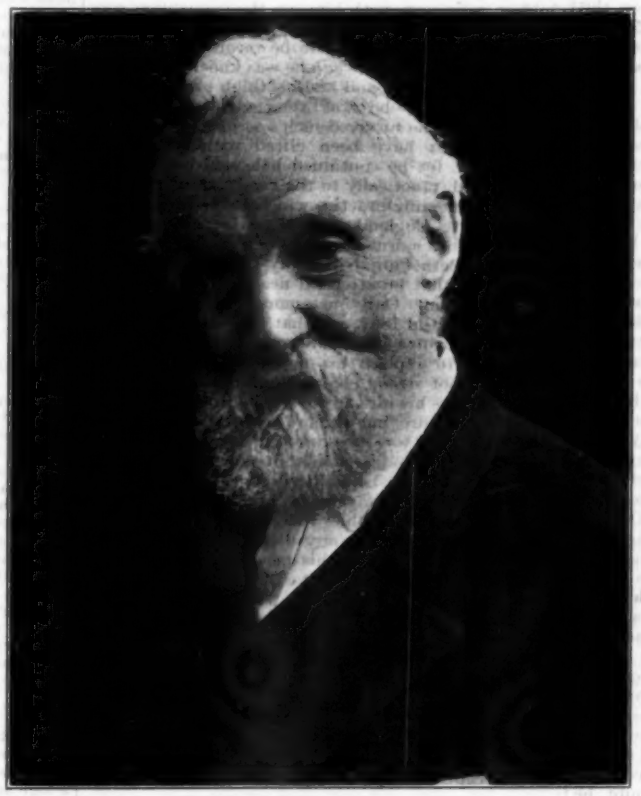
SIR BRADFORD LESLIE.

IT is with great regret that we have to record the death of Sir Bradford Leslie, which took place in London on Sunday last. To the rising generation of engineers Sir Bradford was comparatively unknown, saving by name, for he was born as long ago as August, 1831, and had nearly concluded his ninety-fifth year at the time of his death; yet from the middle to the end of last century, and, indeed, well into the present century, he was famous as one of the most distinguished, as well as the most daring, bridge builders that this country has ever produced. In attaining that reputation, which was richly deserved, he was indebted, to a considerable degree, to the fact that he served his pupilage with I. K. Brunel, himself amongst the greatest of bridge builders of his day; but the lessons he learned from that great teacher only brought into prominence the innate genius for designing and erecting structures of this nature with which he was most certainly endowed.

Bradford Leslie, who was born in London, was the son of Charles Robert Leslie, a Royal Academician and an artist of high reputation. Bradford received his scholastic training, as have many other great men, at the Mercers' School. Fortunately for him, his father had got into touch about that time with Brunel, who was then engaged in the building of the Great Western Railway, and he was able to arrange that the lad, at the age of sixteen, should be apprenticed for a period of five years to that great engineer. Youths in those days were taken from school and put to work in the world at a much earlier age than they are nowadays, and, moreover, if they showed signs of ability they were very soon given positions of trust. When but four of the five years of his apprenticeship had been served Leslie was sent down as assistant engineer for the building of the bridge over the Wye at Chepstow, his special duty being the formation of the pier foundations and the erection of the girders. From Chepstow he was sent to work at the Dock Branch of the Gloucester and Forest of Dean Railways. Possibly, however, the most important work on which he was engaged under Brunel in this country was the erection of the famous Royal Albert Bridge over the Tamar at Saltash. There he was put in charge first of all of the building and then of the launching and sinking of the caisson for the central pier. This structure is 35ft. in diameter and air pressure had to be used for sinking it. Thereafter he continued working at the bridge, which had not been completed when he was recalled to London in 1855. Subsequently he was employed by Mr. Brunel in the construction of the Stony Creek and Salt Water River bridges and other works for the Victoria Railways. Later, on his return to this country, he was, again under Mr. Brunel, engaged in superintending the construction of the heavy forgings for the framing, rudder, engines, anchors, and chain cables for the steamship Great Eastern, at the final successful launching of which, in January, 1858, he played a part.

That same year, 1858, Leslie began what was to prove the main work of his life—railway engineering and bridge building in India. He entered the service of the Eastern Bengal Railway Company, under the late Mr. W. Purdon, in the capacity of Resident Engineer in charge of certain large bridges and viaducts. He was, at that time, it must be remembered, a young man of only twenty-seven years of age. His first stay in India only lasted four years, for on the completion, in 1862, of the particular works on which he was engaged he returned home and was appointed principal engineer for the construction of the Ogmore Valley Railway. In the meantime I. K. Brunel had died in 1859, so that he was unable, as doubtless he would have chosen were it possible, to work again under his old chief. On the completion of the line in 1865 he again entered the service of the Eastern Bengal Railway Company and once more proceeded to India, on that occasion as Chief Resident Engineer for the construction of the Goalundo extension of the railway. The extension, which was completed and opened for service on January 1st, 1871, included one of the bridges with which his name is especially identified, namely, that over the Gorai River.

Here it may be mentioned that in the same year Leslie sought election as a member of the Institution of Civil Engineers, his proposer being R. P. Brereton and among his seconders being W. Purdon, under whom he had served in India, Sir John Hawkshaw, and Harrison Hayter. In February, 1872, he submitted a paper entitled "Account of the Bridge over the Gorai River on the Goalundo Extension of the Eastern Bengal Railway." The reading and discussion of this paper occupied two evenings and it gained for him a Telford Medal and a Telford Premium—a marked distinction for a new member to achieve with his first contribution to the Institution's "Proceedings." In this paper it was explained that at the site of the bridge the river in the dry season is about 1000ft. wide, with a depth of water of 40ft. with a stream of 3 miles per hour. In the rainy season, however, the width is increased to 1600ft., and there is a rise of 28ft., while the velocity of flow is increased to nearly 5 miles an hour, which has the effect of causing the bed of the river to be deepened 24ft., so that the depth of water during floods is upwards of 90ft. The deep channel is on the east side, while on the west side there is a sandbank 500ft. wide, which is dry in the cold season and has 30ft. of water over it in floods. This part of the river was crossed by a screw pile viaduct in nine spans, each of 46ft. 3in., and one half span. Each of the piers consisted of two cast iron piles carrying the superstructure strengthened by two auxiliary piles connected with the centre piles by wrought iron bracing. The main bridge consisted of seven spans, each of 185ft. from centre to centre, carried by eight piers. Six spans crossed the low-water channel of the river, while the seventh was a land opening on the east side. Each pier was composed of two cylinders, placed 37ft. 6in. apart, from centre to centre, that distance being wide enough for the superstructure to carry a double line railway, if required, though, at first, only a single line was laid.



SIR BRADFORD LESLIE

The cylinders had a wrought iron base 30ft. 6in. high, 14ft. in diameter at the bottom, tapering to 13ft. 4in. at the top. On the top was a cast iron taper piece or cone 9ft. high, which reduced the diameter to 10ft., which diameter was continued for the remainder of the height of the pier. The method of sinking employed was invented by Leslie himself. The ground in which they were sunk was of such character that he realised that the sinking would have to be to considerable depth and foresaw that it might possibly be necessary to work under a pressure due to some 100ft. head of water. As a matter of fact some of the piers were sunk to a depth of 98ft. below low water. Pneumatic pressure might, of course, have been used, but in that case the cylinders would have had to be stronger than would otherwise be necessary, and hence, of course, more costly. Leslie therefore decided to sink them by a method of his own. He devised a revolving cutter or "a kind of rotary plough," as he himself termed it, by means of which the soil was excavated from the inside of the cylinder. The apparatus consisted of a horizontal disc plate, with four blades at right angles to each other, projecting vertically beneath the underside of the plate. The blades were triangular in shape and were armed with cutters or ploughs, so that, when it was revolved, the boring head excavated a conical hole 9ft. in diameter. The boring head was bolted to the bottom of a vertical shaft consisting of an annular pipe 13in. inside and 26in. outside diameter in 9ft. lengths. The annular space between the inner and outer pipes was made air-tight, the shaft actually being a vertical pipe surrounded by a series of air jackets, the object being to combine great strength, to sustain torsion, with buoyancy in water. Actually the shaft itself was self-supporting in water and the weight available for forcing the cutters into the earth was the constant weight of the boring head, &c., which sufficed for ordinary working, though for cutting very hard clay it was sometimes necessary to fill one or two lengths of the annular pipe with water. The shaft, which was revolved by a small compressed air engine, was held concentric with the cylinder by top and bottom guide frames, in which it was free to revolve.

Another object of making the boring shaft hollow was to permit of the removal of the excavated soil by means of a current of water constantly flowing up the pipe. For that purpose a 12in. syphon pipe, the inner leg of which was immersed in the boring shaft, and the outer leg in the water in the river, was employed. The requisite current up the hollow boring shaft was obtained by pumping water into the cylinder to a higher level than that in the river. Then, by connecting the suction of the air pumps with the syphon, the air was exhausted from it, and, being replaced by water, a flow of water from the cylinder, which was proportionate to the quantity thrown into the cylinder by two 13in. centrifugal pumps, was established.

We have not space to describe in greater detail the actual sinking operations nor to mention the difficulties due to storms, &c., which were met with and overcome. It must suffice to say that they were eminently successful and that the bridge was completed and is, according to our latest information, still in service exactly in the same form as when it was first opened.

The Gorai Bridge was designed on more or less conventional lines. It was to be quickly followed by another of an entirely different character. The absence of a bridge crossing the Hooghly at Calcutta had by that time been severely felt, but the matter was complicated by the facts that (*a*) at that point the river was tidal; (*b*) that it was subject to severe floods; (*c*) that "bores" coming up from the sea were frequently experienced; and (*d*) that it was necessary to provide for the passage of craft up and down the river. The range of tide is about 6ft. to 7ft. at neaps, and 10ft. to 14ft. at springs. A further variation is caused by the periodical floods, so that there is a total difference of more than 20ft. between the low water of spring tides in the dry season and the high water of spring tides in the rainy season. Moreover, at certain times the "bore" may reach a height of 6ft. and a maximum velocity of 6 miles per hour.

Although, apparently, the matter did not, at the time, actually come within Leslie's province, since the bridge, were it to be built, would not have to carry his railway, yet for some years prior to the building of the Gorai Bridge he had been giving a great deal of thought to the question. The conclusion at which he arrived was that, having regard to the great expense of a fixed bridge, the lengthened period necessary for its construction over a deep and rapid river, with a shifting bed like the Hooghly, and the risk of accident to such a structure from shipping breaking adrift in cyclone and storm waves, it would be much better to build a floating bridge. The latter, he argued, could be more cheaply and expeditiously constructed, in the first instance, than a fixed bridge, and it could be readily repaired in case of accident. During the year 1868 he got out a design for a floating bridge and made a model of it, which was seen by, and caught the fancy of, the then Viceroy, Lord Mayo, when he went to open the Gorai Bridge. The scheme was strenuously opposed by men of experience, who considered it impracticable, an opinion that was shared by many official advisers of the Government. Nevertheless, it was eventually adopted and it was originally proposed that a limited liability company should be formed to carry it into effect. Later the Government took the matter up and decided to undertake the construction through the agency of the local Govern-

ment of Bengal. Work on it was begun in January, 1873, and the bridge was finished and opened for traffic in October, 1874.

At first Mr. William Clarke, the municipal engineer of Calcutta, was in charge of operations, but when he was invalided home Leslie was invited to take his place, and it was under his supervision that the bridge was completed. At the time it was the only bridge of its kind which had ever been attempted. It was 1530ft. long between abutments and had a roadway 48ft. wide, with a footpath 7ft. wide on each side of it, so that the total width between hand rails was 62ft. The floating portion of the bridge was carried on twenty-eight pontoons coupled together in pairs to secure stability. The maximum distance between two coupled pontoons was 48ft. from centre to centre in normal sections of the bridge. The pontoons, which were rectangular iron boxes, were 160ft. long by 10ft. beam, with holds varying from 8ft. to 11ft. in depth, according to the deadweight to be carried. Each pontoon, except those forming the movable sections, with which we shall deal immediately, was anchored fore and aft by 60-cwt. anchors and 75 fathoms of 1¾in. chain cable, laid exactly in line with the centre of the pontoon, the distance between the up and the down-stream anchors being 900ft. For making connection with the shore there was at each side a hinged adjusting way consisting of a bowstring girder span, each span being 160ft. long between the end pins on which they were hinged.

For providing an opening through which vessels of the larger type, such as ocean-going vessels desiring to dry-dock, could pass up and down the river, the two pairs of pontoons in the centre of the bridge were made to be movable so that they could be dropped downstream and hauled sideways out of the fairway. They were connected with the fixed portion of the bridge by means of drawbridges forming part of and operated from the fixed structure. By hauling in these drawbridges and removing the two pairs of pontoons, with, of course, their superstructure of roadway, &c., an opening 200ft. wide was provided. Ordinarily the opening was effected twice a week at high water, but it was occasionally done at low water.

Contrary to the prophecies of the critics, the bridge, though it went through many vicissitudes during its construction, was a complete success and added considerably to its designer's already great reputation. For some little time after its completion Leslie continued to act as municipal engineer of Calcutta and was engaged in such other matters as that post entailed as the carrying out of drainage works and the provision of a water supply. In 1876, however, he was again back at railway work, having been made Agent and Chief Engineer of the East Indian Railway Company. That position he continued to occupy for nearly eleven years, during which he introduced many improvements, including the substitution of cast iron sleepers in place of wood. It is also said that he attained considerable success with the employment of native drivers for goods trains. In this connection, however, it is interesting to record his opinion of the native workman as a whole, which we are able to do in his own words as contained in his reply to a paper on the Hooghly floating bridge, which was read before the Institution of Civil Engineers on March 5th, 1878, and for which we may say, incidentally, he was awarded a Watt Medal and a Telford Premium. He said that "his experience of the native mechanic, artisan, or mistri of Calcutta was not favourable. He had usually found him to be the reverse of skilful, deficient in physical strength, and a lazy, inaccurate, unreliable and expensive workman. No doubt he was, as a rule, docile, and frequently by no means deficient in intelligence; but it required unlimited patience and the closest supervision to secure good workmanship at his hands." Not very good raw material out of which to make good locomotive drivers!

Mention must now be made of still another bridge which brought him fame and, in fact, won for him a knighthood in the form of the K.C.I.E. in 1887. It was again over the Hooghly, and this time it was a railway bridge carrying the East Indian Company's line across the river so as to take it into Calcutta. At the point of crossing the river is 1200ft wide at low tide. The bridge, known as the Jubilee Bridge, since it was completed in 1887, consists, as to its river portion, of a central double cantilever having a length of 380ft. 6in., supported on two cylindrical piers sunk in the bed of the river at a distance apart of 120ft. 6in. from centre to centre, and two shore spans, each 420ft. long. The river ends of each of these spans are carried by the ends of the central cantilever, the shore ends being supported on caisson piers sunk partly in the river and partly on land. The river piers are 66ft. long by 25ft. wide and to provide them two wrought iron caissons, 108ft. high by 66ft. long by 25ft. wide, with semicircular ends and each weighing 453 tons, were employed. They were sunk in some 27ft. to 30ft. of water down to hard yellow clay at a depth of 89ft. below datum—mean sea level—through some 60ft. of silt. The sinking of the caissons was carried out in a manner almost identical with that which Leslie devised for the Gorai Bridge and which we have already described. For further particulars of this interesting bridge we must refer our readers to the paper by Sir Bradford which was read before the Institution of Civil Engineers on January 24th, 1888, and for which he was awarded a George Stephenson Medal and a further Telford Premium. It is interesting to note, however, that in his reply to the discussion Sir Bradford said that his original idea for the bridge was to span the river by two arches springing from a central pier. The arches were intended to be constructed out of old iron rails taken out of the railway as the line was relaid with steel. The old rails, he said, were worth only 36s. a ton at Calcutta, and with the raw material so cheap a very massive bridge could have been erected at a comparatively small outlay, and he was confident that no more stable or durable a structure could have been devised. The proposal, however, did not commend itself to the railway company's consulting engineer and was abandoned in favour of a more orthodox type of construction.

It is impossible in a memoir of this kind to make mention of all the other works carried out by Sir Bradford during his long sojourn in India, but they were many, and among the other bridges, besides those already mentioned, with which he had to do in one capacity or another were the Dufferin Bridge over the Ganges at Benares, and numerous other bridges on the Oudh and Rohilkund and the Sind-Punjab and Delhi Railways, as well as, at an early part of his career, the Echamutter and Koomar River Birdges on the Eastern Bengal Railway.

In 1887, just after the completion of the Jubilee Bridge, Sir Bradford, as the result of repeated attacks of malaria, was invalided home. On the way he suffered shipwreck off Corsica and injured his knee by falling down while carrying one of his grandchildren, who were with him, up the companion way of the liner. That injury caused him to limp for the rest of his life. It may here be recorded, too, that some ten or eleven years ago he was knocked down in the street in London and had his thigh broken. Considering his age—he was then eighty-four—it is wonderful that he survived such a serious injury. He, however, must have been gifted with a splendid constitution, for he continued hale and hearty, and worked hard, practically to the very end, at the consulting engineering practice which he had started on his return to England in 1887. He had, in 1895, been made chairman and engineering adviser to the Southern Punjab Railway Company, and it is said of him that he attended nearly all its meetings held in London. Only once more did he visit India after leaving it in 1887, and that was when in 1899 he went to Calcutta to endeavour to persuade the authorities to replace his original floating bridge, which was not strong enough to carry the increased traffic. It was his idea to substitute for it two others of a similar nature, but of more robust design.

Sir Bradford was possessed of a charming personality, which endeared him to all with whom he came into contact, being particularly happy in his relations with natives. He was of an entirely fearless nature, and no matter how dangerous it might be, he never hesitated in going anywhere or doing anything when he considered that his personal attention was called for. He was, somewhat curiously, having regard to the aptitude he showed at various times during his life to depart from beaten tracks, intolerant of innovations in certain directions. For example, it is said that he refused to have wireless apparatus installed in his house, nor would he use motor cars or taxi-cabs if other means of conveyance were available.

Sir Bradford for some time served as member of Council of the Institution of Civil Engineers, but he never accepted higher office in that body.

JOHN DANIEL.

MR. JOHN DANIEL, a well-known Cornish engineer, died at St. Ives on March 12th. Mr. Daniel began his professional career as a marine engineer, and in that capacity he visited many parts of the world. Later, he turned his attention to mechanical and mining engineering, and at the age of twenty-nine he took up a post on the Kowna and Kalgoorlie goldfields in Western Australia. On his return to this country he was engaged at the Hayford mines and afterwards at the Wheal Mirth, in Cornwall, and during the tin boom of 1906 he was in charge of the opening up and general lay-out of the South Phœnix Mine at Liskeard. He remained associated with that undertaking until 1912, with the exception of a short period when he went to the Argentine to advise on certain mechanical questions at Famatina. From 1912 until 1919 he was general manager of the well-known Ropp tinfields in Nigeria, which were ably managed by him. Before he retired Mr. Daniel had carried out mining surveys of property in Cornwall and other parts of the world, including Columbia and the Gold Coast. He was an associate of the Institute of Mining and Metallurgy and an associate member of the Institution of Mechanical Engineers. He was in his sixtieth year.

CERTAIN operations of the Geodetic Survey of Canada in the eastern provinces of the Dominion were brought to a successful termination last season by the completion of a circuit of 1860 miles of triangulation. The circuit closed at the head of the bay of Fundy with a discrepancy in geographic position of only 42ft., which, averaging as it does about one-quarter of an inch per mile, was considered highly satisfactory.

Water Power Projects in Spain.

SOME interesting information regarding two hydro-electric power schemes in Spain was given in recent issues of *La Revista de Obras Publicas*, from which the information contained in the following article has been prepared.

THE RIVER JUCAR.

The regulation of the river Jucar by means of a reservoir of 35 million cubic metres capacity, which has yet to be provided, will furnish Madrid with some 15,000 horse-power. Some features of the canal which is used for the carriage of timber are of considerable interest, especially the aqueduct across the Rio Frio. The dam for the main reservoir, in the Jucar Valley, will be 33 m. above the finished foundations, the greatest depth of which will be 17 m. From this dam, the foundations of which are being built, the water is taken by a canal to a lagoon, the Laguna de Uña, situated on the top of a steep cliff of the Jucar, and 6 m. above the level of the river. Besides forming a cascade over the cliff, the waters of the lagoon had, until measures were taken to make the bed water-tight, percolated through the strata forming the cliff.

The lagoon is fed by a small, but fairly constant brook, and plays the useful part of balancing the diurnal changes in the demand for power. By increasing its depth by 2 m. the area has been enlarged to three times the natural area and the capacity raised to some 500,000 cubic metres. Some of the new ground to be submerged was very permeable, and measures were taken to render it water-tight. It was covered with a layer of well punned clay, protected by a top layer of soil. The virtual hydraulic gradient from the water of the lagoon near the embankment was flattened by carrying to a considerable depth the clay core of that embankment, this clay core being of considerable thickness. The embankment has a long, pitched slope on the water side, prolonged in a clay apron protected by earth. A part of the embankment, 30 m. long, is of reinforced concrete built over a row of piles driven to firm ground.

From the lagoon there is a canal of large section to the forebay, which has a capacity of 15,000 cubic metres. This canal traverses some difficult ground, making it necessary to use piles in parts of the foundations, and to build the floor and one side at least of reinforced concrete, where the route is along the faces of cliffs. To avoid a very steep piece of ground, it was necessary to deviate in tunnel for 800 m. This canal provides a convenient waterway for the passage of timber obtained in the upper part of the Jucar basin.

The forebay is provided with two scour pipes arranged respectively for the removal of the larger rubbish and the finer silt, and to suit these dispositions the inlet is at the surface. There is a separate pressure chamber, with a sluice which regulates the flow in accordance with the demand for power. This sluice can be left to operate automatically, be worked by hand, or be operated electrically from the power station.

The pressure pipes are 600 m. in length, the diameter diminishing from 1·8 m. to 1·5 m. A steep declivity has been dealt with by means of a cutting and a sharp inclination in the pipes, which also change direction in plan. The turbo-generators and the transformers are in separate buildings. Two sets of the former have been installed, and a third is to be added later. Each set includes a horizontal axis Francis turbine of 7500 horse-power, fitted with an automatic regulator and compensating orifice, and coupled with an alternator of the enclosed type. The voltage is raised from 6000 to 60,000 in two steps, but the transformers are capable of raising it to 85,000, which will be necessary if the line, instead of connecting as it now does with the Madrid network at Bolarque, be carried as a separate transmission line into Madrid.

THE RIO FRIO AQUEDUCT.

The Rio Frio, flowing in a gorge 60 m. deep, known as the Barranco de Madera, lies across the route of the canal from the lagoon to the surge tank. The simple solution of a high aqueduct, to carry the full flow of 10 mecusecs and to allow of the passage of timber along the canal, would have involved the building of a costly masonry structure with foundations of at least corresponding magnitude in the somewhat unfavourable strata of the river bed. The other simple solution, the construction of a "syphon" in the usual manner, would have involved heavy expenditure on concrete protective works in the river bed, and the diversion of a considerable proportion of the flow to furnish sufficient water to float the timber down the river. The work as carried out embodies both types. An open channel of dimensions sufficient for the passage of the timber, is taken across at the higher level, and a syphon pipe, entirely above ground, crosses at about half that height from the river bed. The masonry structure which carries the pipe also carries a steel superstructure which supports the open channel. As compared with a masonry acqueduct of the full height, the length is 120 m., as against 200 m.

The relative heights of the two portions of the work were mainly determined by a comparison of the width of masonry piers necessary to provide bases sufficient to resist the moment of the wind pressure on the superstructure, and the resulting calculated costs of the two parts. A masonry aqueduct of the full height would have been not less than 50 m. high above the river bed for about 60 m. of its length.

The actual dimensions given in the publication referred to above are:—Length of masonry structure, 120 m.; length of steel superstructure, 200 m.; invert of pipe, 35 m. above the lowest point in the river bed; water level in the open channel, 63·5 m. above that point. There are three masonry arches in the river bed and two on each bank, all of about 10 m. clear span at the springings. The masonry of the abutments and of two of the piers is carried to a height of a few metres above the pipe, providing bases for the four steel piers which carry the steel girders supporting the open channel. The central span and the two shore spans are 40 m. in the clear and the other two spans 35 m. The shore spans rest on solid masonry abutments. The proportion of the flow taken by the open channel is not stated, but it is clear that it could be very small indeed.

Institution of Naval Architects.

No. I.

THE annual meeting of the Institution of Naval Architects opened in the Hall of the Royal Society of Arts on Wednesday, March 24th, under the presidency of the Duke of Northumberland.

The report of the Council stated:—

ANNUAL REPORT.

Membership.—The total addition to the roll of membership of the Institution during 1925 was 168, compared with 143 in 1924, although no summer meeting was held in 1925. Owing to the continued depression of the shipbuilding industry, however, the possibility of a decline in the total membership for 1926 must be faced. The total number of deaths and resignations during 1925 was 160, as compared with 157 for 1924.

The annual statement of receipts and payments appended to the report shows that the financial position of the Institution continues to be satisfactory.

A cordial invitation to hold a summer meeting this year in Belgium has been received from the Burgomaster of Antwerp, transmitted through the Belgian Ambassador in London. Arrangements are being made to visit Antwerp and Brussels, and possibly other centres of interest; the date of the meeting has been provisionally fixed for the last week in June.

In accordance with the provisions of Regulation XXI., the Council have passed a resolution enabling ex-enemy members of the Institution who were temporarily removed from the roll of membership in December, 1914, to be re-admitted on application to the Council.

Two premiums have been awarded for papers contributed to the "Transactions" in 1925, viz.:—

Mr. C. Frodsham Holt, D.Eng., for his paper, "Stability and Seaworthiness."

Mr. G. H. Hoffmann, for his paper, "Analysis of Sir John H. Biles's Experiments on H.M.S. Wolf in the Light of Pietzker's Theory."

Status of Engineer Officers in H.M. Navy.—The Council were invited to take action, jointly with other leading Institutions, in approaching the First Lord of the Admiralty (the Right Hon. W. C. Bridgeman) in connection with the Fleet Order No. 3241, dated November 21st, 1925, dealing with the status of naval engineers. A deputation from the leading Engineering Institutions, representing an aggregate membership of nearly 40,000, was received at the Admiralty by the First Lord and two members of the Board on January 14th. The deputation was assured that the arguments put forward in the memoranda submitted would have careful and sympathetic consideration. Nevertheless, the reply subsequently received makes it clear that no departure from the provisions of the Fleet Order in question is contemplated. The Council feel that this question is one of far-reaching importance, not only to the *personnel* of the Navy, but also to the engineering profession generally.

William Froude National Tank.—The Council again call attention to the need for supporting the research fund of the Tank, which during the past year has continued to carry out work of the greatest value to the advancement of naval architecture. Three of the papers which are to be read at the spring meetings are the result of research work carried out at the Tank. The contributions to the research fund so far received fall considerably short of what is needed to carry out the full programme of research work, and unless there is a considerable increase in the amount available for research, the future usefulness of the Tank will be seriously affected. It is hoped that those firms who have not yet subscribed will realise the necessity of doing so in the general interests of the industry.

National Certificates in Naval Architecture.—The proposal to award National Certificates in Naval Architecture, which has been under consideration for some time, has now been agreed to by representatives of the Board of Education, the Institution of Naval Architects, and the Worshipful Company of Shipwrights, and regulations have been drawn up which are being circulated by the Board to the principal educational centres throughout England and Wales. Similar arrangements have been entered into with the Scottish Education Department, and it is hoped that both schemes may be in working order very shortly.

Engineering Joint Council.—The Engineering Joint Council, on which the Institution is represented by Sir John Biles, K.C.B.E., LL.D., D.Sc. (Chairman), and Sir Archibald Denny, Bart., LL.D., have made a recommendation that there should be a preliminary examination common to all the constituent Engineering Institutions in connection with the admission of students. This proposal having been agreed to in principle, it is hoped that a workable scheme may be evolved for giving effect thereto.

It was announced by the Secretary that the Duke of Northumberland had been re-elected President, and that the ballot for vice-presidents and members of Council had resulted as follows:—Vice-presidents: Mr. Summers Hunter and Mr. James Brown. Members of Council: Mr. R. W. Colvill, Mr. A. W. Johns, Mr. James Montgomerie, Engineer-Captain W. Onyon, Mr. H. Ruck-Keene, Mr. A. W. Sampson, Mr. Tom Westgarth, Mr. H. G. Williams, and Mr. Harold Yarrow. Associate members of Council: Professor W. E. Dalby, Mr. A. C. F. Henderson, and Sir Charles Sanders.

The President, in an introductory address, said that the Institution had suffered a great loss in the death of some of its most distinguished members, among them Sir Philip Watts. His loss was certainly an irreparable one, not only for the Institution, but for the country. His name would be handed down to history as the designer of that Navy which fought and won the Great War, and he had left behind him a record of public service which it was given to few men to attain.

The Institution had satisfactorily passed through another year of its existence, notwithstanding the continued depression in shipbuilding. It was hoped that this would before now have reached and passed the lowest point of its ebb tide, but although the industry still continued to suffer severely from lack of orders and empty berths, the Institution itself, being a scientific and not a commercial society, had fortunately escaped the worst consequences of the industrial crisis, which had, however, in many cases caused much hardship to its members individually. There were, though, signs of a possible improvement during the coming year, and the number of orders for new merchant ship tonnage which had been placed during the past few months raised hopes that a point had been reached where a gradual, if slow, recovery in the industry would take place. The orders which had been placed might not be very remunerative, and might not represent at present any large increase in the manual labour that could be employed, but at least they gave some assurance that those who were discharged on the completion of the vessels which were already in hand would not find the shipyard doors closed against them.

Some of the new orders had been obtained in spite of severe foreign competition, but industrial and financial conditions abroad were no longer as unfavourable to chances of tendering against continental shipyards as they were last year. British credit still stood high in the world's financial circles, and British craftsmanship in the shipyards and engineering shops was able, when allowed to give of its best, to turn out work the accuracy and thoroughness of which were second to none. Our troubles largely arose from a combination of circumstances due to very different causes which, coming upon us in the aftermath of the Great War, had proved too much for the industries which were most directly affected. The markets of the world were now, however, slowly recovering, and although the situation in Russia and China was holding up trade revivals in these two great areas, yet other European States and the South American Republics were showing hopeful signs of trade expansion and recovery.

He would add a few words about a subject which was touched upon in the annual report—the status of naval engineers. By a Fleet order issued last November, naval engineers were deprived of the military status which they previously enjoyed, and which they so fully earned by their services during the Great War. In their view, and in the view of the principal societies concerned with engineering, this order would have an unfortunate effect upon that branch of the naval service which was largely represented in the Institution. A feeling of anxiety and indeed of resentment was aroused in naval and engineering circles, and this led to the formation of a committee upon which the principal engineering institutions, aggregating a membership of 40,000, were represented. The deputation of that committee was unsuccessful in its appeal to the Admiralty to rescind the Fleet order in question. The Admiralty contended that no slur or slight upon naval engineer officers was ever intended, but their contention that the grievance was an imaginary one was strongly disputed by those best qualified to judge what the practical effect of the order would be. They hold that it would tend to impair the efficiency of the engineering branch of the Navy and they felt bound therefore to protest against it. In these days, when engineering in some form or other entered into almost every walk of life, when warships, from the largest battleship to the smallest submarine, consisted of a vast and intricate agglomeration of mechanical appliances, when the *personnel* engaged upon engineering duties outnumbered those who were not, it was, in the view of this Institution, an anachronism to emphasise the difference between the executive officer and his engineering colleague, instead of strengthening the bonds of union between them, and so unite into a closer corporate membership all branches of the Service. It was pointed out that other navies had found it possible to bridge over these difficulties, and to give those who had embraced the engineering branch equal opportunities with the deck or executive officers of attaining the highest posts in the Service. It was not, of course, contended that, under present conditions of training and service, engineer officers could aspire to command ships or fleets, although in certain other navies that was the case, but their status would, it was contended, justify their retention among the combatant branches of the Service. It was felt that if on the Board of Admiralty place were found for direct representation of the engineering branch, it would certainly help to make engineers feel that anything affecting that branch of the Service had a spokesman on the ruling body, and that their views would be fully considered.

The meeting then proceeded with the reading and discussion of papers.

THE OUTLOOK FOR SHIPBUILDING.

First on the list was the paper by Mr A. C. F. Henderson, "The Present Outlook for British Shipbuilding," of which an abridgment is given on p. 362.

Sir Westcott Abell, who opened the discussion, said that the paper was a forcible reminder of the intimate relations which must exist between the technical and the economic branches of shipowning and shipbuilding. Mr. Henderson was also to be congratulated on his courage in undertaking the difficult and thankless task of prophet to the industry. He had given the Institution the benefit of certain definite conclusions which he had reached as to the future of British shipbuilding, and he had also given a very condensed account of some of the arguments which had led him to these conclusions. Few would venture to disagree with the correctness of Mr. Henderson's deductions as to the immediate future of shipbuilding and the criticisms which might be made did not really affect the general conclusions to which Mr. Henderson's experience and insight had led him. He had used the variations in the exports of coal from Great Britain as giving some indication of the state of world trade. It was doubtful whether such a use for coal export figures was altogether justifiable. There was, of course, a remarkable similarity between the curves of coal export and of the entrances and clearances of tonnage engaged in British trade; but to argue that this similarity either held good for world trade or would continue in the future was hardly correct. The question of a trade index for the use of the shipbuilding industry was highly complicated, when considered either from the world or from the British point of view. Figures for entrances and clearances were obviously unsuitable. Unfortunately, the total figures of the weight of goods imported and exported were not available, and hence it was impossible to arrive on that basis at any figure of the work done in either weight or volume carrying by the British or the world fleet. Nor would this be a good index of the position of the shipbuilding industry, even if it were available. There was, however, another avenue of approach to the problem; that was the figures of the value of the imports and exports of the various countries of the world. At first sight that would seem to be an equally unsuitable figure, but it was possible to arrive at a figure which represented the fluctuations in the real value of the trade of each particular country. To this should be added the transport of passengers. That was a subject upon which Mr. Henderson was an authority, and it would be interesting to hear his views on what would be a suitable index of the passenger-carrying function of the British and world fleets. A combined passenger and cargo index of that character would show fluctuations roughly corresponding to those of the trade cycle, and as Mr. Henderson stated, the effect of the trade cycle upon shipbuilding was cumulative. He questioned, however, the statement that fluctuations in tonnage figures followed fluctuations in trade figures. There was, of course, a close relationship between the two, but actually it would be found that shipowners had to anticipate trade movements, and that if it were possible to obtain an index of the orders booked by the shipbuilding companies, it would be found to move either one way or the other considerably in advance of trade movements. It could be shown that with suitable modifications for scale and for other factors, the curve of shipbuilding output was the differential or rate of change of the curve of tonnage owned. Most of those present were only too painfully aware of the distressing tendency of a differential curve to magnify variations in the parent curve. He would emphasise the importance of the evidence concerning the movements in shipbuilding output which were foreshadowed in the figures published each year by Lloyd's Register of Shipping. He did not venture to contravene Mr. Henderson's conclusions, but only some of the arguments on which they were based.

Sir John Thornycroft said that Mr. Henderson had claimed for the British shipbuilding industry the best craftsmen in the world, but what was the value of this asset if it was not possible to use it to the best advantage. Unless shipbuilders could reduce their production costs they could not withstand many more years of existing conditions in the industry. It was possible to carry out the suggestion made in the interim report of the Joint Committee on Shipbuilding, and obtain greater elasticity and interchangeability in working conditions without, he believed, infringing any broad principle of craftsmanship. The rules which now governed demarcation were known to have a great effect in enhancing shipbuilding costs in Great Britain as compared with the costs of construction in foreign yards. The Joint Committee's report not only emphasised that fact, but included in the report was a whole series of recommendations concerning interchangeability. No action had yet been taken, but he gathered that Sir Charles Sanders, the secretary of the Shipbuilding Employers' Federation, was rather pleased with the progress which had been made by the Joint Committee. Unfortunately, some of the trade unions, instead of helping the reform movement, appeared to use their power to make demarcation troubles more difficult. It was certain that as long as they existed it would be very difficult for British shipbuilders to face foreign competition. He had heard complaints from shipowners abroad who would be willing to place orders in British yards that the terms quoted could not be accepted. That was the kind of thing which was going on all the time. It was quite as necessary for this economic aspect of the situation to be dealt with by the Institution as that the scientific development of design should find a place among the subjects discussed.

Mr. John Barr welcomed the attempt to evolve a formula which would enable those connected with the shipbuilding industry to decide with some sense of security what the immediate future might have in store. With regard to the inquiry now in progress in co-operation with the trade unions, the work promised to accomplish a good deal towards securing a return by the British branch of the industry to its old place in world shipbuilding. A study of the paper would direct the thoughts of many people into channels which might assist towards a solution of the difficult problems involved.

Sir Archibald Denny pleaded for the more effective co-operation of shipowners and shipbuilders to bring about the standardisation of the details of construction in shipbuilding and marine engineering. Shipowners had, owing no doubt to depressed trading

conditions, been less disposed during a recent period to subscribe to the work of the Engineering Standards Association. Standardisation of the kind he had in mind would be a great advantage to the shipbuilder in making tenders for new ships, and the shipowner would get exactly what he wanted. On the subject of the statistical position, it had been pointed out by Mr. Robert Clark, the chairman of the British Corporation Register, that for a long period the trade of the world had been carried in about 30,000 ships, of which about 12,000 were of less than 1000 tons each. During a recent period the average tonnage of the units of this world fleet had tended to become larger. At the moment it was clear that the number and the total tonnage of the ships available for the trade of the world was too great. Mr. Kempster, of Messrs. Harland and Wolff, had shown that in the British merchant fleet there was a tonnage of 1,300,000 over twenty-five years old, and a scheme was put forward by which arrangement could be made to scrap many of these vessels. If the survey were extended to ships of twenty years old and upwards, it would be found that there were 788 vessels in that category, aggregating 3,000,000 tons. Of that tonnage he estimated that there were 200 ships, aggregating 1,000,000 tons, which might be broken up if a scheme could be devised which would provide some compensation to owners. It might be possible to do something of that kind on the basis of granting special facilities for the building of one ton of new shipping for every two old tons scrapped.

Mr. J. T. Batey also referred to the inquiry which is being conducted into the position of the shipbuilding industry. He thought it would be agreed that within the industry every endeavour was being made to reduce building costs, but it was essential that attention should be given to the conditions external to the industry which swelled construction costs in British shipyards, and over which the shipbuilder had no direct control. There was this gleam of hope concerning the present position. Things could not get worse, and it was thought that signs of improvement could be discerned. He was heartily in favour of the policy of greater collaboration between shipowner and shipbuilder, so that the shipping industry could be put in possession of the most economical types of ships and maintain the prestige of the British merchant service.

Mr. A. T. Wall, dealing with the statistical position, said that since the year 1919 the output of foreign yards had dropped more than that of home yards. With regard to the falling off in orders from abroad, facts must be faced. Shipbuilding costs were lower on the Continent than in Great Britain and Ireland, largely because the standards of living and wages were lower abroad, and although attempts were being made to raise those standards it would be a long time before the levels which had been attained in Great Britain were reached. Speaking from personal knowledge, he could say it would be a mistake to belittle the capabilities of foreign yards, and their workers. With regard to the future, it was unfortunate that the reduction in output coincided with an increased capacity for production in British establishments. At the present time, only 60 per cent. of the workers available were employed; if the whole of them found employment and the output increased *pro rata*, British yards would make a yearly production of 1,800,000 tons—a figure which had been reached in very few years. It was clear that the small addition to the yearly output predicted in the paper would not absorb the workers available, who exceeded the number required to produce the average annual tonnage. The addition to the number of merchant shipyard hands was no doubt partly explained by the practical cessation of the building of vessels of war.

Mr. Henderson replied briefly to the discussion. He said that he agreed that the figure taken for the trade index was not a good one, but it was the only one he could get at the time. He did not, however, think that Sir Westcott Abell's scheme was free from objection, and he doubted whether a figure of real value could be arrived at. The figures for passenger business could be obtained, as the numbers in all classes were available. With regard to shipbuilding costs, he thought that they had been got down to bottom level now, and that the industry should take a turn for the better. In connection with standardisation, shipowners were curious people, and had their little fads and fancies. Standardisation was no doubt very desirable, but he feared that human nature would prevent the result desired being achieved.

Launching Problems.

Mr. W. J. Berry, Director of Naval Construction, read a paper dealing with the "Launching of H.M.SS. Nelson and Rodney," of which an abridgment is appended.

LAUNCHING ARRANGEMENTS OF H.M. SHIPS NELSON AND RODNEY.

Nelson and Rodney are the first ships to be designed and built to a standard displacement of 35,000 tons, the limit laid down for capital ships by the Washington Treaty on the Limitation of Armaments.

The keel plate of H.M.S. Nelson was laid at Messrs. Armstrong's naval yard, Walker-on-Tyne, on December 28th, 1922, and that of H.M.S. Rodney at Messrs. Cammell Laird's shipyard, Birkenhead, on the same date. Nelson was launched on September 3rd, 1925, and Rodney on December 17th, 1925. Both vessels were retained on the building slip till they were in a more advanced state of completion, for both hull and machinery, than is usual for battleships, and the armour was practically all on board; as a result the launching weight was approximately 20,000 tons, a very considerable figure in view of the length between perpendiculars being only 660ft. This launching weight was exceeded by about 2000 tons in H.M.S. Hood and by about 5000 tons in U.S.S. Saratoga, but in these ships the weight was carried on a much greater length.

Having regard to the launching weight and its distribution longitudinally, and more particularly, transversely, the side armour being on board, the builders proposed launching on four ways, the arrangements adopted in the two ships, after discussion with the Admiralty, being shown in Fig. 1. General particulars are given in Table I.

Thorough investigations to estimate the condition of the ship at launch and the probable forces acting were made for two heights of tide, about 3in. and 15in. respectively below the expected high tide, the lower tide being in the neighbourhood of what was considered to be the minimum safe launching tide.

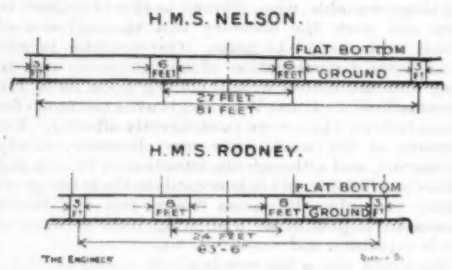


FIG. 1

The actual tide at the launch of H.M.S. Nelson was 2½in. higher than the expected high tide, giving a height of water 13ft. 5½in. over the way end. The actual tide at launch of Rodney was 1in. below the lower of the two tides considered, the height of water over the way end being 12ft.

Table I.

	Nelson.	Rodney.
Length between perpendiculars, feet	660	660
Declivity of keel, inch per foot	¼	0·503
Declivity of chord of ways, inch per foot	35,64	37·3,64
Camber of ways	18in. in 717ft.	24in. in 715ft.
Length of ground ways (inner), feet	717	715
Length of ground ways (outer), feet	533	521
Length of sliding ways (inner), feet	542	570·5
Length of sliding ways (outer), feet	245	216
Breadth of ways (each) (inner), feet	6	8
Breadth of ways (each) (outer), feet	3	3
Area of sliding surface, square feet	7,974	10,424
Ways apart outside to outside (inner), feet	33	32
Ways apart outside to outside (outer), feet	84	66·5
Fore edge of poppet from fore perpendicular, feet	76	65·6
Launching weight used in calculations (hull and contents only), tons	18,860	20,500
C.G. abaft amidships, feet	56·1	53
Water on way end	12ft. 1in.	12ft. 1in.
Poppet from way end when stern lifts, feet	189	198·5
Weight on poppet when stern lifts, tons	2,650	2,535
Weight on poppet at way end, tons	230	273
Mean initial pressure on grease, tons per square foot	2·435	1·97
Pressure on grease when stern lifts, tons per square foot, taken on a length of 16ft.	13·8	9·9
Maximum load per foot run on way end during passage of mid-body, tons	119	156·6
Corresponding pressure on grease, tons per square foot	9·91	7·12
Least moment against tipping, tons-feet	280,000	270,000

After the launch the case of Nelson was again investigated in view of the actual conditions which obtained on the day of the launch. The principal results obtained from launching curves have been embodied in Tables I. and II. In Table I. results are also given for Rodney, assuming height of water over way

Table II.

	Nelson.
Launching weight used in calculations, tons (Hull and contents, saddles, fore stopping and sliding ways)	19,780
C.G. abaft amidships, feet	55·4
Water on way end	13ft. 5½in.
Poppet from way end when stern lifts, feet	212·5
Weight on poppet when stern lifts, tons	2,580
Weight on poppet at way end, tons	Nil
Mean initial pressure on grease, tons per square foot	2·495
Pressure on grease when stern lifts, tons per square foot	13·44
Maximum load per foot run on way end during passage of mid-body, tons	66
Corresponding pressure on grease, tons per square foot	5·5
Least moment against tipping, tons-feet	405,000

end to be 12ft. 1in. It will be noticed that the exceptionally high tide which gave 16½in. more water over the way end than was assumed in the first calculation for Nelson very materially modified the results obtained.

An investigation was made to ascertain the maximum longitudinal bending moments and stresses that the ship might experience during her passage down the ways. For this purpose the lower of the two tides assumed in the calculations prior to launch was adopted, namely, a height of tide 12ft. 1in. over way end.

A curve was drawn giving the longitudinal weight distribution of the ship. For the supporting forces the launch was assumed to be slow and the ship considered to be in equilibrium when at various positions on the ways. At each position the longitudinal distribution of the supporting force of buoyancy and pressure on the ways was calculated. Then by successive integration of the difference between the weight and supporting curves, a curve of bending moment acting on the ship at each position was obtained. The envelope of these curves was taken to represent the maximum bending moment that any section of the ship might experience. The principal results may be summarised as follows:—

Hogging.—The maximum bending moment anticipated with tide line 12ft. 1in. above way end was about 560,000 tons-feet, its position being somewhat abaft amidships. Adopting the usual method of calculating stresses, this gave:—Tensile stress in upper deck = 7·3 tons per square inch; and the compressive stress in outer bottom = 4·9 tons per square inch.

Sagging.—The maximum bending moment anticipated was about 210,000 tons-feet, its position being about 90ft. before amidships. At the position considered above for hogging the maximum sagging moment was 150,000 tons-feet, giving the following stresses at that section:—Compressive stress in upper deck = 1·1 tons per square inch; and the tensile stress in outer bottom = 1·5 tons per square inch.

The actual height of tide at launch of Nelson was 1ft. 4½in. higher than the tide assumed in the original strength calculations, and the effect of this on the calculated results is as follows:—

Hogging.—The maximum bending moment was reduced to 420,000 tons-feet, the corresponding stresses being: Tension in upper deck = 5·5 tons per square inch; and the compression in keel = 3·7 tons per square inch.

Sagging.—Except that the stern lifts after a shorter run, the sagging bending moments were not appreciably affected by the rise of tide. Hence the maximum calculated stresses in the upper deck at the position selected with the actual tide at launch became 5·5 tons per square inch tension and 1·1 tons per square inch compression. In view of the high estimated hogging stresses it was decided to take stress measurements during launch, using for this purpose, four in number, Fereday-Palmer strain recorders. The four instruments were arranged in a line across the upper deck about 20ft. abaft amidships, two port and two starboard.

Launching Speeds.—Observations were made to enable a space-time curve of the ship to be plotted from which the velocity and acceleration of the ship during the travel down the ways were obtained. Curves for Nelson are shown on Fig. 2 and are plotted to a base of distance run. The ship reached a maximum velocity of 18·8ft. per second after a run of about 320ft., and the acceleration attained a maximum value of 0·8ft. per second

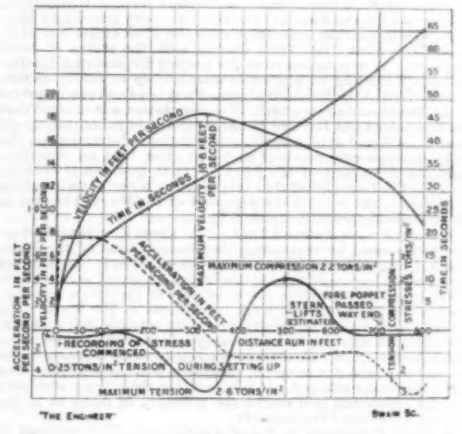

ACCELERATION IN FEET PER SECOND PER SECOND
VELOCITY IN FEET PER SECOND
TIME IN SECONDS
VELOCITY IN FEET PER SECOND
TIME IN SECONDS
ACCELERATION IN FEET PER SECOND PER SECOND
MAXIMUM VELOCITY 18·8 FEET PER SECOND
MAXIMUM COMPRESSION 2·2 TONS/IN²
STERN LIFTS ESTIMATED
FORE POPPET PASSED WAY END
RECORDING OF STRESS COMMENCED
DISTANCE RUN IN FEET
0·25 TONS/IN² TENSION DURING SETTING UP
MAXIMUM TENSION 2·6 TONS/IN²
TENSION
COMPRESSION
STRESS IN TONS/IN²
TIME IN SECONDS
THE ENGINEER

FIG. 2

per second after a very short run, and retained this value for a run of nearly 100ft. The estimated coefficients of friction are 0·045 initial and 0·021 sliding. After passing the position of maximum velocity the retardation soon became practically constant at about 0·23ft. per second per second. Shortly after the fore poppet passed the after end of ways the retardation increased to about 0·55ft. per second per second; at this stage the first pair of drags had commenced to act.

At the launch of Rodney the acceleration was measured direct by means of an apparatus designed by Professor T. B. Abell, of Liverpool University. The results obtained were very similar to those obtained for Nelson by the usual methods.

The results obtained by the four strain recording instruments were in close agreement with one another. A mean of the four curves plotted to a base of distance run is given on Fig. 2. On the same base are shown curves of time and velocity and acceleration of ship. The following points are noted:—

(1) Maximum tensile stress recorded = 2·6 tons per square inch, and occurs after a run of about 326ft., at which point the position selected is still 117ft. from way end. (It was anticipated that the maximum stress would occur after a run of about 400ft.)

This stress combined with the strength modulus of the section may be taken to represent a bending moment of 200,000 tons-feet instead of 420,000 tons-feet, the estimated maximum, *i.e.*, a reduction of 220,000 tons-feet.

(2) Maximum compressive stress recorded = 2·2 tons per square inch and occurs after a run of about 500ft., at which point it was estimated the stern would lift at 13ft. 5½in. tide.

This stress represents a bending moment of 300,000 tons-feet instead of 150,000 tons-feet, the estimated maximum, *i.e.*, a gain of 150,000 tons-feet.

In short, the maximum tensile stress recorded is only one-half of that estimated, whereas the maximum compressive stress recorded is double that estimated.

A factor that may have a bearing on this result is the method of taking account of armour and protective plating when estimating the inertia of the section. This was entirely neglected under tension but included under compression, and it is considered that this probably under-estimated the inertia of the section when hogging, and thereby over-estimated the stress, the reverse happening under sagging.

A further point with regard to the calculation of the moment of inertia of the section is that a deduction of two-elevenths of the material under tension was made in order to allow for rivet holes. It is probable that this deduction also tended to over-estimate the tensile stress in the upper deck at the position selected, as the instruments were placed between two frame stations, not spanning a line of rivet holes.

The factor, however, which probably had the most important bearing on the results is the effect of the forces brought into play by the passage of the ship into the water. It will be observed from Fig. 2 that the maximum velocity of the ship down the ways was 18·8ft. per second, equal to a speed of 11·1 knots. Clearly a vessel thrust stern first into water at this speed will meet with a substantial resistance. Calculations showed that the dynamic forces exerted by the water on the stern of the ship during the run account for a large proportion of the difference between the calculated and measured stresses. This result is reassuring in cases where the hogging stresses calculated by the usual methods are high.

Internal fortifications were arranged throughout the length of the ship, particular attention being paid to the portions of the hull where the upward pressure per unit area obtained on the usual assumptions was expected to be considerable. At the lower of the two tides mentioned previously a possible pressure

of 10 tons per square foot had to be provided for over the 'midship portion of Nelson. Under the actual conditions obtaining at launch 5¼ tons per square foot was the estimated maximum pressure in this neighbourhood. The pressure per square foot on the fore poppet when the stern lifted, assumed to be uniform over a length of 16ft., was about 13½ tons, this figure being little influenced by the rise of tide.

Melted tallow to a thickness of about ¼in. was applied over the ground ways. Next a coat composed of three parts of tallow to one part oil was applied, following which were two coats composed of half tallow and half oil. Patches of soft soap at close intervals were then placed on the ground ways over the whole length of the sliding ways, and finally oil was sprinkled over the whole of the surfaces so treated. In addition, two coats of tallow were applied to the bottom surfaces of the sliding ways before these were pulled into position.

Owing to the restricted width of the river, it was necessary to ensure that Nelson should be brought to rest after a run of not more than 350ft. subsequent to the stem passing the after end of the ground ways. Eight drags were placed on each side of the ship, the total weight being 1162 tons. The first pair of drags was arranged to act when the stem of the ship was still about 50ft. from the way end and the remaining drags came into operation in pairs after further runs of 25ft. between each pair. Actually the ship was brought to rest before the last pair of drags began to act.

No drags were necessary at the launch of Rodney, the width of the river being ample in this case.

For Nelson the holding, releasing and starting gear consisted of :—One dog-shore to each of the inner ways, two dog-shores to each of the outer ways, two 150-ton hydraulic holding and releasing triggers to each of the inner ways, two 100-ton hydraulic starting jacks to each of the inner ways, two 40-ton hydraulic starting jacks to each of the outer ways.

For Rodney :—One 200-ton and two 150-ton hydraulic holding and releasing triggers to each of the inner ways, one 100-ton hydraulic starting jack to each of the inner ways. On releasing the triggers both ships immediately started down the ways, without aid from the starting jacks.

The "breakage" of each ship in launching, both lingitudinally and transversely, was found to be nil, and no structural damage of any sort was sustained. The launch in the case of both ships was entirely successful, and each firm is to be heartily congratulated on the splendid result obtained.

Mr. W. J. Luke referred to the great responsibility which rested on those in charge of the launching of large ships. In the cases of the Nelson and Rodney, it was fortunate that a considerable head of water was available at the end of the ways. With regard to the pressures on the grease, he noted it was in the case of the ships dealt with in the paper 2·6 tons and 2·7 tons per square foot, and in the case of the Hood it was 2·45 tons. When the Aquitania was launched, the pressure was 2·27 tons per square foot, but in that instance the ways were larger than those from which the Nelson and Rodney were put into the water. Mr. Berry gave the weights on the fore poppet when the sterns of the latest capital ships lifted as 2600 tons ; in the case of the Hood and Aquitania it was 5000 tons. It would be of interest if Mr. Berry could include in the paper the figures for the Hood. On the general subject of the pressure on the grease, they had been taught that 3 tons per square foot should be the maximum. It was important in cold weather to warm up the grease, even if the temperature was not down to freezing point. He recalled the case of a cargo vessel 400ft. long which, from neglect of that precaution, took fifteen minutes to move 100ft.

Mr. H. G. Williams commented on the fact that the launches of the Nelson and Rodney were on four ways instead of two, which was a departure from precedent that could not be lightly undertaken. It was quite easy to make a sliding surface of any number of ways, but it was always open to doubt whether so satisfactory a distribution of the pressures would be obtained as with two ways only. The decision to employ four ways was made on account of the great beam of the ships. The chief risks in launching ships were, however, of what might be regarded as an accidental character, such as the failure of the tide to rise, the melting of the tallow on hot days, the sticking of the ship from other reasons, and the breaking of drag wires. A drag wire did actually break in one case, but no harm was done.

Professor Percy Hillhouse also referred to the pressure on the after end of the ways. The estimate was 9·9 tons, and the actual pressure 5·5 tons in one case and 7·12 tons per square foot in the other. In the Transylvania the figure was 11·2 tons ; in the Aorangi, 21·3 tons ; submarine E 38, 19·5 tons ; Renown, 5·33 tons ; and Valiant, 7·25 tons per square foot. A better figure than tons per square foot was tons per frame space. Mr. Berry distributed the pressure on the fore poppet over a length of 16ft. A more usual figure, he thought, was 30ft. He would like more details of Professor Abell's speed-recording instrument.

Mr. E. L. Atwood said that the need for four ways launching was due to the excessive overhang of the vessels and the transverse distribution of weight, owing to the side armour being in position. It was an open question whether there was not an unequal distribution of pressure and a heavy demand on the outer ways, but it was thought that the weight would even out and prevent the pressure per square foot from being excessive at any point. He had an idea that the pressure on the outward ways might be enough to squeeze the grease out, but it was clear that the tallow would withstand pressures up to 7 tons per square foot without cracking. The information given in the paper was a valuable addition to knowledge concerning launching problems.

Professor T. B. Abell, in a written contribution, referred to the instrument used to measure the acceleration, which was of more importance than the distance run. It was shown that the stern of the ship would lift appreciably earlier than the estimated moment of lift, and in the case of the Nelson he thought it took place after travelling about 400ft. instead of 500ft., as estimated. After the stern lifted, the changes in resistance from moment to moment would be very small, and the acceleration would become more and more uniform. The early lift of the stern involved an increase of pressure on the fore poppet beyond that estimated, and required a much larger reinforcement of the ground ways than would be derived from actual static calculation.

Mr. W. J. Berry, in reply, said that he would give the Hood figures for addition to the paper. In recent cruisers launched the pressure on the grease had been from 2·5 tons to 1·5 tons per square foot, but there was a little reluctance on the part of some of the ships to move off. The quality of the grease was not so good as before the war, and that fact must be taken into account in looking at the pressures recorded.

The meeting then adjourned until the following day.

The annual dinner was held on Wednesday evening under the presidency of the Duke of Northumberland.

In giving the toast of "The Royal Navy," the President said that there was a tendency to try and reduce the Navy to a point where it could not fulfil its *rôle* of defending the Empire.

Mr. J. C. C. Davidson, Parliamentary Secretary to the Navy, replied.

Vice-Admiral Sir E. Chatfield proposed "The Mercantile Marine," which was acknowledged in an interesting speech by Mr. Walter Runciman, who said that although merchant ships were being operated at very little profit, shipowners carried on by reason of their faith in the future.

Lord Eustace Percy gave the toast of "The Scientific and Engineering Societies," to which Sir William Ellis (President of the Institution of Civil Engineers) responded. In doing so, he pressed the claim of naval engineers to be restored to their old status of the enjoyment of military rank.

JUNIOR INSTITUTION OF ENGINEERS.

On Friday evening, March 19th, a paper on "Pipework : Its Manufacture and Lay-out," was given, before the Junior Institution of Engineers, by Mr. G. H. Willett, member of the Birmingham Local Section. Cast iron pipes were dealt with first. They were, it was stated, chiefly used for low-pressure water, gas and exhaust steam, and should never be used for high pressure or superheated steam. Wrought iron and steel pipes were next discussed, the different methods of welding pipes and also the making of weldless tubes being described by the aid of lantern slides. The author then went on to say that the jointing together of lengths of pipes constituted a serious problem, and that many types of joints had been evolved. They, however, resolved themselves into four main divisions, viz., spigot and socket, screwed and socket, flanged and welded. Each of these types and its uses were described, and particulars given of the variation necessary for pipes of different materials and the conveyance of different fluids.

The design of pipe lay-outs was next reviewed, with particular reference to the methods of supporting the pipes, to insulation and to the provision for expansion. The chief source of danger in a steam main was, the author said, the problem of drainage, and the design should be such that any condensed steam which might collect, whether in commission or when steam was shut off and the main had cooled down, could be drawn off automatically by steam traps at as few points as possible. Various pipe lay-outs to obtain that result, together with the necessary steam traps, valves and other fittings, were then described.

SIXTY YEARS AGO.

On March 17th, 1866, an attempt was made to launch H.M.S. Northumberland, an ironclad built at Millwall. The attempt was a complete failure. The deadweight of the hull was 9200 tons, and with the exception of the Great Eastern, the vessel was the heaviest that, up to the time, it had ever been attempted to send down a single pair of ways into the water. It would appear that in view of her weight the inclination of the launching ways had been reduced below the usual amount, and from what subsequently took place it would seem that the reduction had been carried too far. Dealing with the matter in our issue of March 23rd, 1866, we reported that for some 40ft. or 50ft. the pace of the vessel on the ways was rapid, but that before she had gone a hundred feet her speed slackened and the vessel eventually came to a stop, with about half her hull in the water. She was immediately shored up with struts, and on the following day at high tide an effort was made to complete her launch. Two hawsers were taken across the river to the opposite bank and attached to capstans each worked by sixty men. Eleven tugs lent their assistance, but still the vessel remained immovable. For nearly a fortnight she was allowed to rest where she was until with the return of the spring tides a renewed attempt to get her off the ways was made on March 31st. For this effort twelve specially constructed wooden pontoons, eight lighters, and nearly four hundred empty puncheons were attached by chains to the stern of the vessel at low water, the whole—"the most unusual and heterogeneous mass of objects that ever surrounded a ship"—being calculated to give a lift of about 1000 tons. Three hydraulic rams, each of 600 tons capacity, were placed at the bows, two to thrust in the direction of the ways and one to lift upwards. A dredger was moored in mid stream with a steam capstan on board and from it hawsers were taken to the vessel. The pull of these hawsers, estimated at 100 tons, was reinforced by two teams of sixteen horses each yoked by a double purchase to the ship's sides. To the accompaniment of bugle calls and "with a quiet good order that seemed almost like military training," the attempt was begun when the tide was at its very height, and some of the lighters were in danger of sinking. The vessel had lifted by about 2in. at the stern, but she was still held fast at the bows. The horse tackle and the hawsers from the dredger snapped and the timber backing of one of the rams was crushed to splinters. Not one inch would the vessel move. The signal drum was beaten, the attempt was stopped, and the vessel once again shored up. Two days later, on Easter Monday, efforts were renewed under the same conditions, except that two battering rams, each worked by fifty men, were rigged at the bows to start the vessel by their concussion. The battering rams thundered against the bows until they smoked and split. The hydraulic presses worked until the backing was again crushed in. The horses tugged until they broke their harness. Finally six of the eight lighters at the stern broke loose. Not the slightest movement of the ship resulted. It was exactly a month after the first attempt, namely, on April 17th, that the Northumberland was successfully sent into the water. On that day the tide available was the highest of the year, and was such as to give nearly 8ft. of water under the vessel's bow, as she hung on the ways. Four horizontal and three vertical rams were used, and the buoyancy contributed by the pontoons, &c., was increased to 1600 tons. Since that date other vessels have stuck on the ways, but we doubt if any have required or been accorded more strenuous or more spectacular means of completing the launch.

STANDARD SPECIFICATIONS FOR PAINT MATERIALS.

The British Engineering Standards Association has just issued British standard specifications for genuine dry white lead and genuine white lead oil paste for use in paint manufacture. They contain clauses regulating the composition, together with standard reception tests for the purchase of genuine white lead in dry and paste form respectively, and appendices giving methods of carrying out the tests. These specifications have been prepared at the request of the paint manufacturers by a committee representative of both the buying and manufacturing interests, and are the first to be published of a series of specifications for paints, varnishes and paint materials.

As in the case of all British standard specifications, they will be reviewed as experience of their working or progress in the industry renders it necessary, and revised issues will be published from time to time. Amongst other specifications in hand which will be published as completed are the following :—

Painting materials : Raw, boiled and refined linseed oil, turpentine, white spirit, red lead, zinc oxide, zinc oxide oil paste, barytes, asbestine, red oxides of iron, lead chromes and Prussian blues. Ready-mixed linseed oil paints : White lead, tinted white lead, zinc oxide, tinted zinc oxide, black, green and red oxide of iron. Oil varnishes : Interior, exterior, rubbing and extra hard drying. Copies of the new specifications—Nos. 239 and 241, 1926—can be obtained from the B.E.S.A. Publications Department, 28, Victoria-street, London, S.W. 1, price 1s. 2d. each post free.

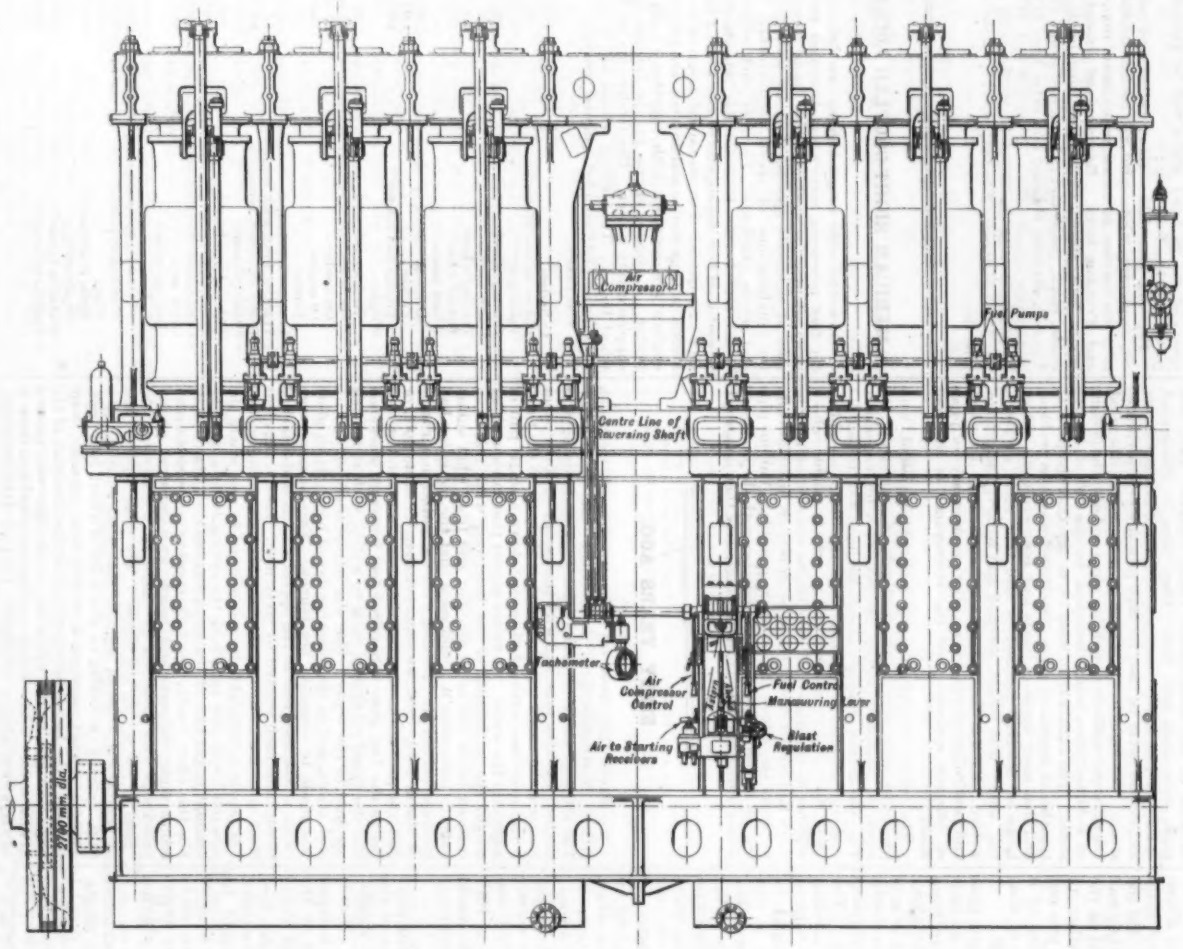
AMERICAN EIGHT-COUPLED LOCOMOTIVES.

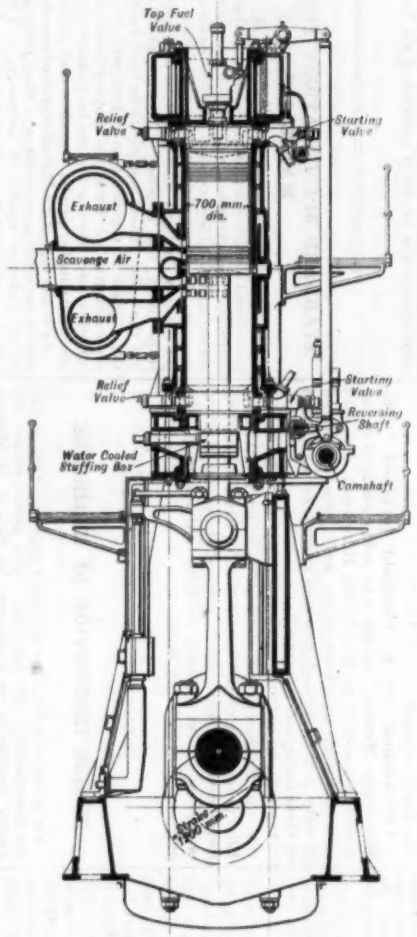
Although eight-coupled engines are not used frequently for fast passenger service on American railways, being more adapted for working heavy trains over severe gradients at moderate speeds, they are used to some extent for combinations of speed requirements, heavy loads and severe gradients. To meet such requirements, the Texas and Pacific Railroad has introduced some very powerful oil-burning engines of the 4 : 8 : 2 type to replace 4 : 6 : 2 engines. For sustained tractive power at high speeds, a large boiler and fire-box are provided, and the engines are quipped with superheater and feed-water heater. A booster engine on the trailing bogie supplies supplementary power. The tenders are mounted on six-wheel bogies. The driving wheels are larger than those of French eight-coupled engines recently described in The Engineer.

Cylinders	27in. × 30in.
Piston valves, diameter	14in.
Valve gear	Walschaerts
Driving wheels	6ft. 1in.
Bogie wheels	3ft.
Trailing wheels	4ft. 3in.
Tender wheels	3ft.
Wheel base—	
Driving	20ft.
Engine	43ft. 3in.
Engine and tender	84ft.
Weight—	
On drivers	122 tons
On bogie	31 tons
On trailer	27 tons
Of engine	180 tons
Tender	123 tons
Tractive force	53,500 lb.
Tractive force with booster	63,700 lb.
Boiler diameter, minimum	6ft. 6in.
Boiler pressure	210 lb.
Tubes, 175 ; length	20ft. 6in.
Fire-box	10ft. × 8ft.
Combustion chamber, length	6ft. 1in.
Grate area	80 sq. feet
Heating surface—	
Tubes	2102 sq. feet
Fire-box and combustion chamber	334 sq. feet
Fire-box syphons	70 sq. feet
Flues	1262 sq. feet
Total evaporative	3768 sq. feet
Superheating	1110 sq. feet
Water in tender	2000 U.S. gallons
Fuel oil in tender	5000 U.S. gallons

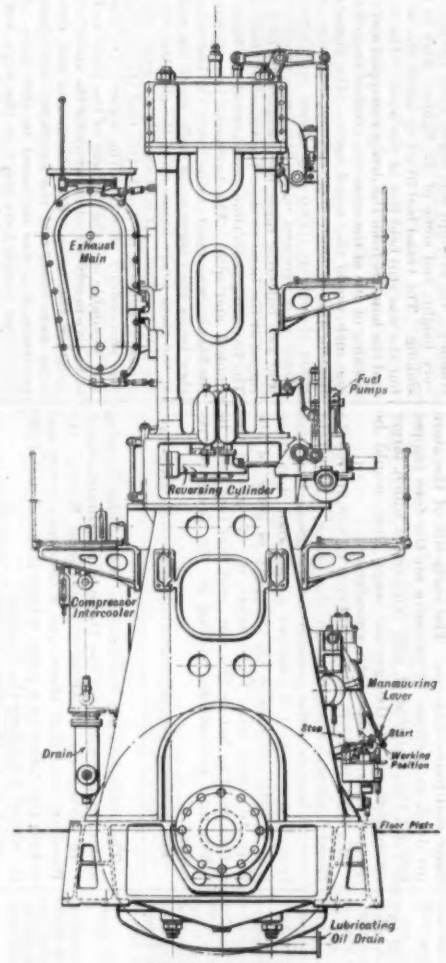
DOUBLE-ACTING TWO-CYCLE SIX-CYLINDER MARINE OIL ENGINE

MASCHINENFABRIK AUGSBURG-NURNBERG A.G., ENGINEERS

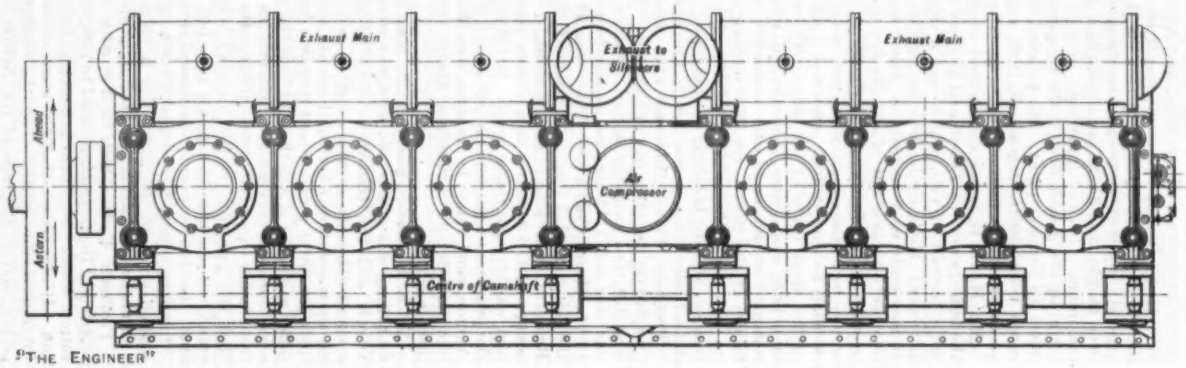




SECTION THROUGH CYLINDER



END VIEW OF ENGINE



"THE ENGINEER"

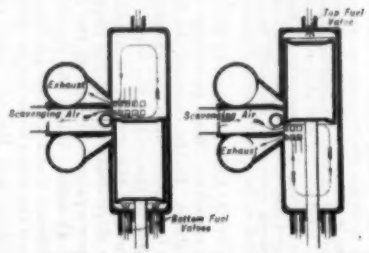


DIAGRAM OF SCAVENGING ARRANGEMENTS

PRINCIPAL DIMENSIONS AND PARTICULARS

Overall Length	11·3 Metres
Overall Breadth	3·7 ,,
Height from Camshaft Centre	8·5 ,,
Overall Height from underside of Bedplate Flange	9·3 ,,
Diameter of Cylinders	700 Millimetres
Piston Stroke	1200 ,,
Number of Cylinders	6
Designed Output	4400 B.H.P.
Normal Speed	94 R.P.M.
Mean Effective Pressure B.H.P.	4·5 Kg. per Sq.Cm.
Weight of Engine including Flywheel, Turning Gear, Blast, Receiver, Scavenge Air & Exhaust Pipes	485 Metric Tons
Weight of Two Motor Driven Scavenging Blowers with Piping	10 ,, ,,
Weight of Cooling Water & Lub. Oil Pumps	9 ,, ,,
Total Weight	504 ,,

SWAIN Sc.

The M.A.N. Double-acting Marine Oil Engine.

No. I.

THE works of the Maschinenfabrik Augsburg-Nürnberg A.G., at Augsburg, in South Germany, may be considered to be the home of the Diesel oil engine. It was at these works, between the years 1893 and 1897, that as a result of difficult and prolonged pioneer work the theoretical designs of the late Dr. Rudolph Diesel were translated into a prime mover with commercial possibilities. The first engine was built and tested in 1897, but shortly before then constructional licences were granted to various firms, both on the Continent and in Great Britain. It is from about that time that the development of the land and marine Diesel engine as we know it to-day was begun.

With its wide experience in oil engine building, it was to be expected that the M.A.N. company would made a significant contribution towards the problem of the best type of marine oil engine for large powers. For this reason, we were pleased to avail ourselves of the firm's recent invitation to see on test at Augsburg a representative example of the new type of double-acting marine engine which is being constructed in Germany and other countries. In the present article we shall describe the engine and in a second article the results of the trials will be given.

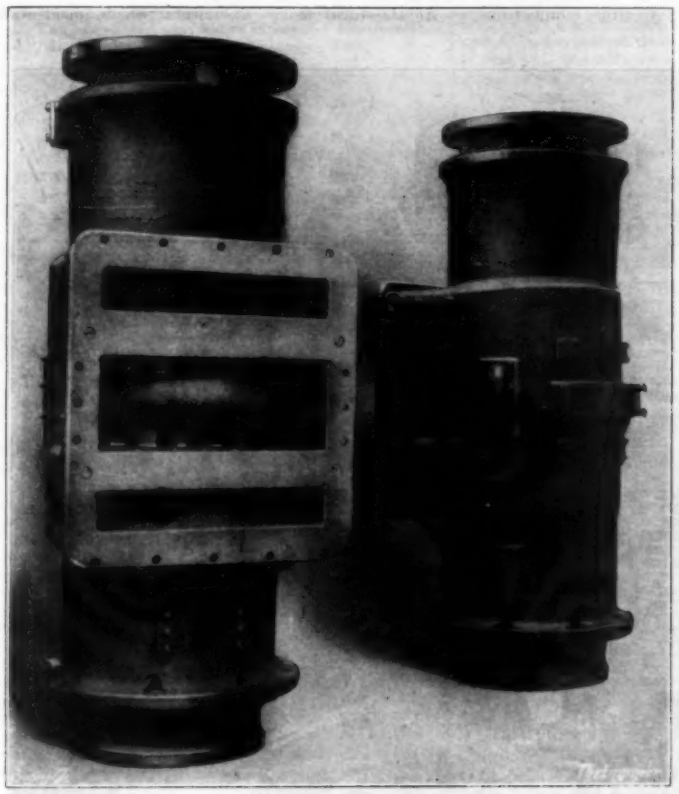


FIG. 1—CYLINDER CASINGS WITH LINERS

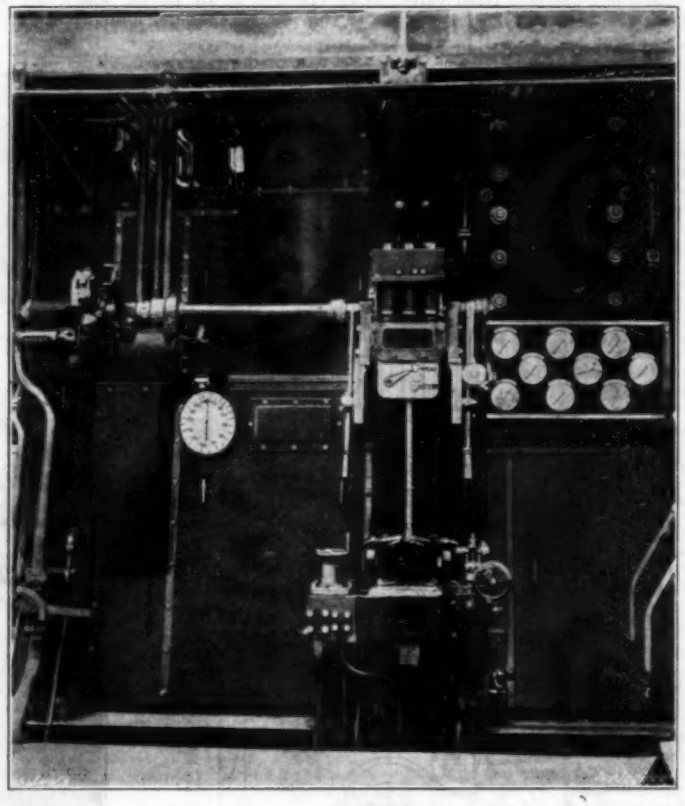


FIG. 2—ENGINE CONTROLS

THE NEW DESIGN.

The new M.A.N. marine oil engine operates on the two-cycle double-acting principle, with port scavenging, a type of engine which the designers rightly claim offers the widest scope for the future development of large engines. Up to the present, the largest size of cylinder unit built on the two-cycle principle develops 2000 brake horse-power, and the largest engine is designed for an output of 15,000 brake horse-power. The present description, however, is concerned with a marine engine of medium output, designed to develop 4400 brake horse-power in six cylinders, when running at the comparatively low speed of 84 revolutions per minute.

It will be readily admitted that the most important point in the production of a successful two-cycle engine is efficient scavenging; particularly in the lower cylinder of the double-acting engine, where the piston-rod must be taken into account. After making careful experiments and investigations, which have extended over many years, the M.A.N. company has now introduced a system of air scavenging by means of which in a simple manner the combustion spaces of the cylinder are completely swept clean of burnt products, and freshly charged with air. The efficiency of this system is such, we learn, that a fuel consumption equal to the best four-cycle practice is readily obtained. The section through the engine on the opposite page, and the diagrammatic view below it, show the arrangement of the air and exhaust ports, and the path of the scavenging air through the top and the bottom cylinders. The scavenging arrangement is patented, and is protected in England under the British patent No. 186,678. It will be seen that the exhaust and scavenge air ports are arranged on the same side of the cylinder, so as to extend about half-way around the cylinder wall. The scavenge ports are designed to deflect the air over the face of the piston, so that it passes along the wall of the opposite side of the cylinder, around the face of the cylinder cover, and returns on the same side of the cylinder as that by which it entered.

Another important feature of the new design is the way in which the main framing is built up. The drawings reproduced on the opposite page show the arrangement of the engine frames, while the general appearance of the engine and particularly the top structure can be seen from the two engravings on page 356. The special construction employed is also the subject of patents, and it is covered in England by the British patent No. 234,046. One of the main objects of the design was the removal of any tensional stress imposed by the cylinder forces in the cast iron columns which connect the bed-plate with the entablatures. Again, it was sought to free the cylinder casings and the liners from any stress in the axial direction—see the vertical section of the engine reproduced on page 352. The framing of the engine consists essentially of sets of narrow cast iron columns, which are tied together at the level of the upper and lower cylinder covers by cross members. It will be seen that steel stay-bolts are run from the top entablature through to the underside of the bed-plate casting. They are generously dimensioned to carry the tensile stresses. Only the compression stresses are taken by the cast iron members. The cylinder casing and liners—shown in the front and back views, Fig. 1—are so attached to the main framing that they are free to expand under heat. The combustion pressures from the top cylinders are taken by the stay bolts, and the top entablature, whilst the pressures in the bottom cylinder have opposed to them the resistance of the columns and the bedplate.

On page 352 we give a plan and elevations of the engine and a section through one of the cylinders. The bed-plate is of the box pattern complete with an oil sump fitted with the usual drain connections. It may be made in sections, bolted together, as occasion demands. Besides carrying the main crank shaft bearings, the caps of which are secured with long screwed bolts to the underside of the foundation plate, the bed-plate is provided with seatings for the through stay-bolts. A built-up crank shaft is employed, each crank pin unit with its two crank cheeks being a single forging. The reciprocating parts do not call for extended mention. Crosshead guides, which are provided with white metalled faces, are carried between each pair of the lower columns, and they serve also as stiffening members for the entire structure. The bottom vertical columns carry the lower entablature to which the cylinder casings are attached by flanges. The casings are free to move in an upward direction, so that they can expand under heat. The top columns tie together the upper and lower entablatures and the whole structure is secured to the bed-plate by the through stay-bolts aforementioned.

Reverting to the vertical section through the engine on page 352, it will be seen that an upper and a lower cylinder liner is fitted. Where the liners meet at the centre of the cylinder, they overlap in a zig-zag formation, so that a free and unhindered run for the piston rings is provided. The piston has a dished top, and the usual piston rings are fitted to it, at the top and the bottom. The bottom cylinder liner with the cylinder casing is attached by a flanged piece to the lower entablature, while the top cylinder liner is secured to the upper entablature and depends from it. In this manner each liner is fastened only at one of its ends, ample room for expansion being provided at the middle joint.

In the case of the cylinder covers a similar separation of the working and heat stresses is sought. The parts in contact with the combustion spaces are water-cooled, so that the heat stresses are limited in magnitude, whilst the cylinder forces are taken by ribbed cast steel pieces, which are secured to the upper and lower entablatures respectively. Care has been taken so to design the cylinder covers that they can be removed without disturbing the main structure. Each cover is built in two parts which can quickly be dismantled, thereby facilitating examination and cleaning.

VALVE GEAR AND FUEL PUMPS.

The top cylinder cover, which is shown quite well in the upper view reproduced on page 356, is fitted with a central fuel valve, whilst opposite one another are placed the starting valve and a cylinder relief valve respectively. The bottom cover carries, besides the valves, the piston-rod stuffing-box. In the bottom cover of the cylinder there are arranged four horizontal fuel valves, which are slightly angled, so as to give good fuel distribution, and to promote turbulence in the annular combustion space between the piston-rod and the cylinder walls. Besides the four fuel valves, a starting valve and a relief valve, similar to those in the top cover, are provided. The horizontal arrangement of the valves in the covers permits of a simple construction being employed, as will be noted from the engine drawings.

It may be mentioned that the stuffing-box is designed according to M.A.N. large gas engine practice. It contains a series of spring-guided cast iron rings of special metal. We are informed that the box required no attention in operation, and has worked very satisfactorily.

The cam shaft is driven from the crank shaft through an intermediate shaft by means of bevel and spur gears. It is arranged along the front of the engine at about the level of the lower entablature, and it carries the ahead and astern cams for the starting valves and fuel pumps. Reversing, which will be referred to later, is effected by sliding the cam shaft so that the required cam is brought into position under the rollers. Referring to the fuel valves themselves, it may be stated that they are of the needle and pulveriser type, designed for air injection. The starting valves are fitted with an air dashpot arrange-

ment, which prevents them from opening when the pressure in the cylinder is higher than that in the starting air pipe. By this means it is found possible to allow the fuel pumps to operate during the starting period. When once combustion takes place the supply of starting air automatically ceases, so that an undue amount of air is not used.

The fuel pumps, of which there are two, one for the top and the other for the bottom end of each cylinder, are mounted on a cast iron stool directly over the cam shaft. The position of the pumps is shown in the drawings on page 352, and a section through one of them is reproduced in Fig. 3. The steel fuel pump plunger fits into a lapped guide, and is spring-loaded. It rests on the top of a piston, to the crosshead pin of which the quadrant lever carrying the fuel cam is attached. At the same time the quadrant is connected by a short link to the reversing and manœuvring shaft, which lifts the rollers while the ahead or astern positions of the cam are given. The fuel pump is provided with a suction valve and two delivery valves, whilst a suction valve-lifting device is also fitted, by means of which the pump can be put out of action when desired. At each stroke the plunger delivers the same amount of fuel oil, but the amount actually delivered to the fuel valves is regulated by the mechanically-operated relief valve, which opens at a certain point on the delivery stroke of the plunger and by-passes the oil to the pump suction. The point at which the relief valve opens is controlled by the load on the engine, but hand regulation through the fuel control lever is also provided. All fuel pipes and distributors are designed so that no air pockets can be formed, and each fuel connection is furnished with a test cock, and a check valve, so that if necessary the delivery of oil to the cylinder can be stopped and the fuel valve opened out while the engine is running. For the fuel valves—four in number—in the bottom cylinder cover a special fuel distributor is fitted to give equal distribution of oil to each valve. The design of the fuel pump is such that the period of fuel injection coincides with that of the working stroke, just before combustion begins. Such an arrangement has considerable advantages, both when starting and also when running at slow speeds, as it avoids the occurrence of high cylinder pressures, which may arise from the presence of fuel oil in the cylinder before injection actually takes place.

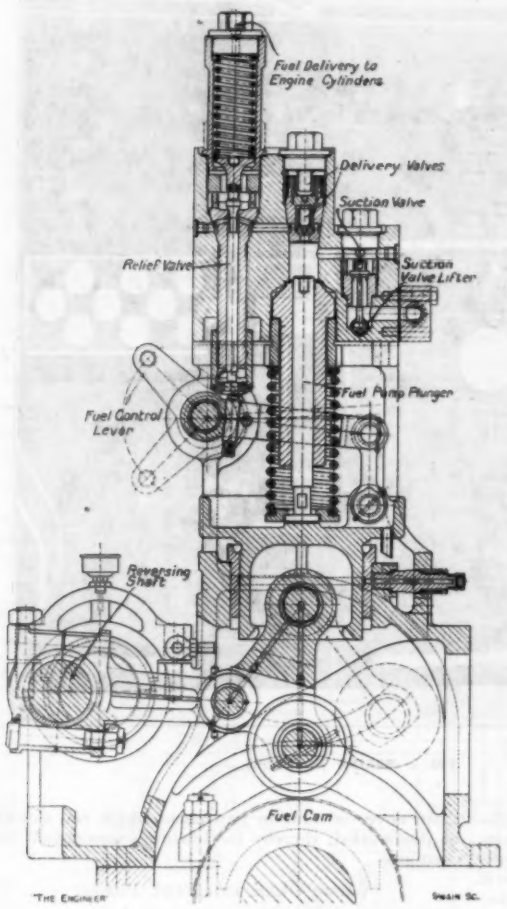


FIG. 3—SECTION THROUGH FUEL PUMP

FIG. 4—THE ENGINE ON THE TEST BED

ENGINE CONTROLS AND AUXILIARIES.

The starting controls can be seen in Fig. 2. The engine is reversed by hydro-pneumatic means. At the fly-wheel end, on the outside of the column a pneumatically-controlled cylinder, filled with lubricating oil, is fitted. The cylinder operates a rack gear, which, in turn, imparts to the cam shaft a sliding movement, bringing the head or astern cam into the due account thus being taken of any engine movement. The scavenging blowers used on the trials were of the Brown-Boveri high-speed electrically-driven type, but for units up to, say, 9000 brake horse-power, reciprocating scavenge pumps can be used. Above that power it is probable that turbo-blowers or disc blowers will prove more suitable. Important auxiliary services are those for the cooling water and the lubricating oil. Particular care has been taken in designing the cooling system and pressure is employed so that high velocities with greater cooling effect are obtained in all important parts. The piston is water cooled, and the connection is made by telescopic pipes, which are so designed that no contamination of the lubricating oil in the crank chamber can take place. All parts of the engine, with the exception of small levers and pins, are lubricated under pressure, the service being maintained by a rotary pump of the gear type. The forced lubrication system includes an oil cooler and an oil filter in circuit with the main oil connections. At the after end of the engine is fitted a small fly-wheel which is furnished with teeth, into which the pinion of the turning gear meshes. The turning gear was electrically operated. For the purpose of absorbing the power developed, the engine was coupled direct to an arrangement of gears built by Thyssen and Co., which gave the correct speed increase for three separate generator units, by which the output of the engine was measured. The arrangement adopted is shown in Fig. 4, which represents an end view of the engine taken on the occasion of the test.

In the present article a brief description of the construction of the engine has been given, and in the second article we shall deal more particularly with the results obtained during the recent tests and the future development of this new type of engine.

Electricity in the Home.

EVER since the British Electrical Development Association came into existence, endeavours have been made at popular exhibitions to demonstrate to the public of this country the advantages to be derived from the use of electricity in the home. Needless to say, propaganda of this nature is of no small importance to engineers, for the more electricity is utilised for domestic and industrial purposes, the greater will be the demand for generating plant. During its period of existence the Electrical Development Association has undoubtedly done excellent work in spite of the imperfections of the electricity supply system of this country. Under the direction of Mr. J. W. Beauchamp, very effective propaganda work has been carried out, and we are pleased to note that the Association is now receiving much more substantial support than it did at the time of its inception.

At the Ideal Home Exhibition, which, incidentally, closes on Saturday, March 27th, the Association has a very elaborate electric house, in which various uses of electricity are shown to advantage. The structure consists of seven rooms, two of which are designed to show old-fashioned methods in vogue fifty years ago. There is an old-fashioned living-room and kitchen, the remaining five sections, consisting of modern electrically-fitted living, bed and bath rooms, a kitchen and a laundry. The comfort, convenience and labour-saving properties of electricity are readily appreciated by those who make a tour of the house, which does great credit to those who were responsible for the exhibit. In all the modern rooms a complete range of electrical appliances is in operation. The lighting of the house forms a special and interesting feature, and demonstrates the merits of various forms of direct and indirect lighting. Electric heating is also represented by examples of the most modern types of radiant fires, sun-ray standards, converters and heat accumulator apparatus. Continuous demonstrations of electric cookery take place in the modern kitchen, where there are many semi-portable and table cookery appliances. One of the chief attractions of the bedroom is a time switch in circuit with an electrically operated singing bird, which awakens the sleeper in the morning and at the same time switches on an electric fire. Time switches can, of course, be employed for many other purposes in the home.

SOME experiments carried out in Canada show that if from 2 to 5 per cent. of lime is mixed with ordinary earth in making a dirt road, mud and ruts are very materially reduced, while maintenance is made easier.

Railway Matters.

UNDER powers obtained in 1923 the Southern Railway is being widened between Eastleigh and Shawford, *i.e.*, towards London, on both sides of the existing double line. The total length is 2 miles 6 furlongs 8 chains, and the work involves the widening of ten underbridges. The work is well in hand.

THE coroner for the borough of Bedford has concluded his inquiry into the Fenny Stratford level-crossing disaster of December 7th. Three of the injured people subsequently died in Bedford Hospital. The verdict returned was death by misadventure, due to an error of judgment by the driver of the motor vehicle.

THE report for the first year of the amalgamated company known as the Great Southern Railways Company (of Ireland) has to record a decrease in receipts of £689,345, mainly owing to the depression in trade, reduced charging powers and motor competition. On the other hand, the expenditure was reduced by £435,646.

ANSWERING a question on the 16th inst., Colonel Moore-Brabazon, the Parliamentary Secretary to the Ministry of Transport, said that the colour light signals for controlling road traffic into and along Piccadilly, between the Ritz Hotel and Burlington House, would be brought into use at a comparatively early date. The signals in question are similar to those now being used on railways, where the indications are given by red, yellow and green coloured lights. Their proposed purpose in Piccadilly was described in our "Miscellanea" column on February 26th.

WHAT are known as "chain letters"—the sending of a letter to a person who is requested to send a copy to a certain number of others—are a great nuisance, and most objectionable when they convey a threat as to what might happen were the chain to be broken. A useful purpose may, however, be served by the chain letter which has been started by an American railway officer pledging the writer to cross level-crossings cautiously, to practise "safety first," and to "do everything in my power to save a life or prevent an injury to my fellow-men."

WE have always had in view the possibility of a passenger train ferry, similar to that between Trelleborg and Sassnitz, that would take passenger vehicles and post-office vans from Holyhead to Kingstown, and, the change of gauge having been provided for, to run through trains between Euston and Galway. The journey thence to America could then be made with only three nights at sea. For that reason we are glad to see that during the eight months ended on December 31st last, the Harwich–Zeebrugge train ferry made a profit of £8908, as against a loss during the previous eleven months of £19,351.

OWING to the successful results achieved by the "Garratt" locomotives supplied by Beyer, Peacock and Co., Ltd., Gorton Foundry, Manchester, to the South African Railways Administration, one of these fast engines—stated to be the highest powered high-speed engine in Africa—was recently assigned for the 436 miles covered by the Cape Town–Port Elizabeth Mail. The engine hauled, to the greatest satisfaction of the railway officials, the heaviest load ever brought into Cape Town; indeed, the load was 75 tons heavier than the recently imported "Mountain"—American—engines had ever drawn.

STUDENTS of the railway companies' annual reports would, we feel sure, be obliged if the Great Western and Southern companies would show the percentage of expenditure to traffic receipts of the three heads that make up the total for maintenance and renewal of rolling stock and of the two heads that cover locomotive running and traffic expenses. The London, Midland and Scottish and the London and North-Eastern give the percentages for the five items named. The London, Midland and Scottish has now improved the financial summary on the front page of its report by giving the corresponding figures of the previous year.

THE American record for safety in railway travel, both as regards passengers and servants, is gradually improving. In 1904 270 passengers were killed in train accidents—that must have been an unusually good year in that respect, as in 1907 there were 610—in 1914 the number was 441, but in 1924 the figure had dropped to 149. In 1904 49,712,503 passenger miles were run to each passenger killed; in 1914 there were 152,401,815; but in 1924 the average reached 244,642,919. In 1904 one man out of each 357 employed on the railway was killed whilst on duty; by 1914 the proportion had improved to one in 538; but by 1924 it had risen to one in 1164.

IN our issue of February 19th we quoted some remarks of Colonel Francis, the storekeeper of the Southern Railway, as to the huge sums standing to the credit of the four British railways for stores and materials on hand. We find that at the end of 1924 these stores were of the value of £23,580,880, and at the end of 1925 of the value of £23,750,180. That increase was despite a reduction of £950,000 by the London and North-Eastern. The Great Western had an increase of £546,000 and the Southern one of £397,000. Whilst it is possible that on the general principle the companies are not sufficiently careful in this matter, it must be remembered that in order to help trade, they have been somewhat generous for the last two years with their orders.

THE railway statistics for the month of December last of the Ministry of Transport, recently issued as a Stationery Office publication, show that, compared with December, 1924, there was a decrease of 0·4 per cent. in the number of passenger journeys, and of 3·3 per cent. in the passenger receipts. Moreover, there was an increase of 3·3 per cent. in the passenger-train mileage. The total tonnage of freight had an increase of 0·9 per cent., of which coal, coke and patent fuel achieved the gratifying rise of 2·5 per cent. The total ton-miles increased by 2·6 per cent., but the freight receipts, probably owing to the increase being in the lower rated mineral traffic, fell by 0·8 per cent. The freight train miles were 1·1 per cent. more than in December, 1924, and the average train load increased from 130¼ to 132 tons. The latter would, we anticipate, again be due to more coal traffic, whilst the fall in the net ton-miles per engine hour from 413⅞ to 395 was, we expect, due to the snowstorms last December.

Notes and Memoranda.

A WRITER in a recent issue of *Glückauf* presented statistics to show that the number of accidents in connection with electrical winding engines was less than in the case of steam winding engines. The reason for this, the writer argues, is that the electrical drive does not try the rope so much as does the steam engine.

AN article in the *Engineering News Record* demonstrates the fact that it would not be possible to form a sixth Great Lake in Canada, as has been proposed by Mr. C. L. Campbell, for the purpose of diverting the waters of the Albany and Ogoki into Lake Superior. The maximum area of such a lake would be, according to our contemporary, 6000 square miles, instead of Mr. Campbell's 15,000 square miles, and it would require very long dams as much as 200ft. high.

DURING the construction of the Exchequer Dam across the river Merced, in California, the flow of the river has been passed through two openings 10ft. wide by 30ft. high. In order to close these openings two concrete gates, each weighing 75 tons, have been constructed and hung by cables near the top of the dam. When the time arrives the cables are to be cut by means of the acetylene blow-pipe, and it is hoped that the energy of the fall will be sufficient to carry the gates right down to their seatings.

ACCORDING to the *South African Engineer*, the City Deep, Ltd., has placed an order for what will probably be the largest electric hoist in the world. It will consist of two cylindro-conical drums measuring 18ft. in diameter at one end, and 35ft. in diameter at the other. To these drums there will be direct-coupled two electric motors each rated at 2400 horse-power; the hoist will, however, be capable of dealing with a peak of 9000 horse-power. It will run normally at a speed of 33 revolutions per minute, winding from a depth of 4500ft. a load of 10 tons of rock.

ARMY tank gunners, now may, it is claimed, watch machine guns, rifle and pistol muzzles firing, gaze at on-coming bullets and see them deflected within a foot of their eyes, as a result of a new bullet-proof screen developed by officers of the United States Army Ordnance Department. The device is a mushroom-like cap of steel, with a series of saw cuts an inch apart. These cuts are too narrow to permit vision when the shield is at rest, but in use it rotates at high speed, and they blend into a band of light, through which the operator in the tank turret may see perfectly. Bullets striking the whirling steel are, it is stated, shattered and flung aside even if they land directly on one of the cuts in the steel.

IN the course of a paper on "Lubricating Oils," read before the Chemical Engineering Group, Mr. J. E. Hackford said that he doubted if the statement that "oil knows no fatigue" could be accepted. Oil itself, as distinct from asphaltum, may be regarded as a hydrocarbon soluble in equal parts of ethyl ether and ethyl alcohol. During the oxidation of oil, with the formation of acidity, asphaltum is also produced, as is already well known. The recovery of a spent lubricating oil by any of the ordinary methods involves the removal of the acidity, water, dirt, &c., but none of the methods removes asphaltum so formed. With the increase of the asphaltum content, which has no lubricating properties, the quality of the oil must deteriorate and therefore the oil show signs of fatigue.

ACCORDING to Dr. Donald M. Marvin, one of Canada's leading economists, the consumption per head of electric power in Canada is twice that of any other country. Canada, he states, utilises 23,000,000 kilowatt-hours daily. A striking illustration of the efficiency of the publicly-owned Ontario Electric Commission, is afforded at the international bridge over the Niagara River. The United States half of the bridge is lit by power generated from the Niagara Falls by an American company. At the centre of the bridge are two street lamps, side by side, and identical. One of them, lit with current supplied by the American company, costs 43 dollars per annum, while the other, which is lit by the Commission, costs 8 dollars per annum, although in both cases the source of current is the Niagara River.

THE two largest hoists ever made in Canada are, according to the *Iron and Coal Trades Review*, shortly to be put to work at Timmins by the Hollinger Consolidated Mines, Ltd. These hoists have a capacity of 560 tons of ore per hour from a depth of 3200ft. to the surface, or of 12,440 tons per day. This is more than double the present mill capacity of the Hollinger Mine and 50 per cent. above the statement of an ultimate mill capacity of 8000 tons a day, which the Hollinger management hopes to attain. Both these hoists, with their complete mechanical and electrical equipment, are being supplied by the English Electric Company of Canada, Ltd. The heavy equipment has just been completed in Great Britain. The steel hoist drums are 12ft. in diameter and 12ft. wide. A third hoist for the new McIntyre shaft is also being made in England at the present time.

THE Government's Lead Paint (Protection against Poisoning) Bill, of which the text has just been issued, gives to the Home Secretary power to make regulations:—(*a*) To prohibit the use of any lead compound except in the form of paste or of paint ready for use; (*b*) to prevent danger arising from the application of lead paint in the form of spray; (*c*) to prevent so far as practicable danger arising from dust caused by dry rubbing down and scraping; (*d*) to provide for the medical examination of persons employed in or in connection with painting with lead paint, and to suspend from such employment persons whose health is or appears likely to be injuriously affected thereby; (*e*) to secure that facilities for washing during, and on cessation of, work are afforded to persons employed in painting; (*f*) to insure the use of protective clothing by persons so employed and to prevent clothes left off during work from being soiled by paint; and (*g*) to ensure the distribution to persons so employed of instructions with regard to hygienic precautions to be taken. Clause 2 prohibits, after November 19th, 1927, the employment of women and young persons to paint buildings with lead paint with the exception of apprentices in the painting trade under improved arrangements and women or young persons engaged in decorative or other work excluded from the provisions of this section.

Miscellanea.

BOTH the shafts of the Betteshanger Colliery, Kent, are down some 950ft., and it is hoped to reach the coal by the end of this year.

IT is proposed to put up a large plant for the fixation of atmospheric nitrogen near Sydney, New South Wales. The Haber process will probably be adopted.

THE total water-borne shipments of lumber from British Columbia last year amounted to 577,560,288ft., compared with the former record of 531,262,318ft. established in 1924.

THE Harbour Board of Napier, New Zealand, is considering the expenditure of £487,236 on the construction of a breakwater to form a harbour capable of accommodating four ocean liners.

THE Town Council of Bo'ness, Linlithgowshire, is taking steps to restore and preserve the small house, situated on Kinneil Estate, in which James Watt perfected his model of the steam engine in 1768.

A COLOGNE report states that the important electrical power undertakings at Manheim and Ludwigshafen have practically concluded negotiations for a loan of four million dollars, which is shortly to be issued in Chicago and New York. The money is to be used for extensions of the works.

WORK on the reinforced concrete wharf, which is being erected at Zanzibar, has progressed so far that the superstructure is being started, all the piles having been driven. The wharf will be 800ft. long and will be equipped with six electric cranes and an oil fuel main connected with the Government tanks. It was started five years ago.

THE Council of Ministers has consented to the construction of 4000 miles of new roadways in different parts of Spain at an estimated cost of 530,000,000 pesetas. While it is stipulated that as much native material as possible is to be employed, no restrictions will be placed on the purchaser abroad of necessary machinery and equipment.

A NEW rotor ship is expected at the port of Hamburg in July. The order for the vessel was given last year by the Naval Administration and the Robert M. Sloman, Jun., Shipping Company to the Weserwerft firm, and it is expected that she will leave the stocks in April. The ship will be of about 3000 tons, and will be equipped with three rotor towers, so that it will be much bigger than the first vessel of this kind, the Buckau, which is of only 630 tons. The Buckau, which is lying at present in Kiel Harbour, will leave shortly, it is said, with a cargo of 300 tons of building stone, probably for New York.

ACCORDING to a message from Venice, a plan has been submitted to the Italian Government for the complete re-organisation of that port. A new governing body, to be known as the Azienda, is to be constituted, consisting of representatives of the municipal government, the various district governments, and the Chambers of Commerce of Venice and the principal inland towns utilising the ports. The Azienda will also consult with other local commercial and industrial organisations, including the Società Porto Industriale di Benezia, a concessionary company, which has charge of the extensions of the port on the mainland.

IN the report of the Royal Commission on the Coal Industry, 1925, summarised in our issue of March 19th, the following passage occurs:—The Mining Association with the British Engineering Standards Association, has recently set out to standardise colliery plant and equipment, and the work is proceeding through Committees of those concerned with the manufacture and use of such plant. It is perhaps the most important general inquiry in which the industry has in recent times been engaged, and in view of the multifarious types of plant and equipment now used at different collieries for similar purposes, it may be expected to yield valuable gains in efficiency and economy.

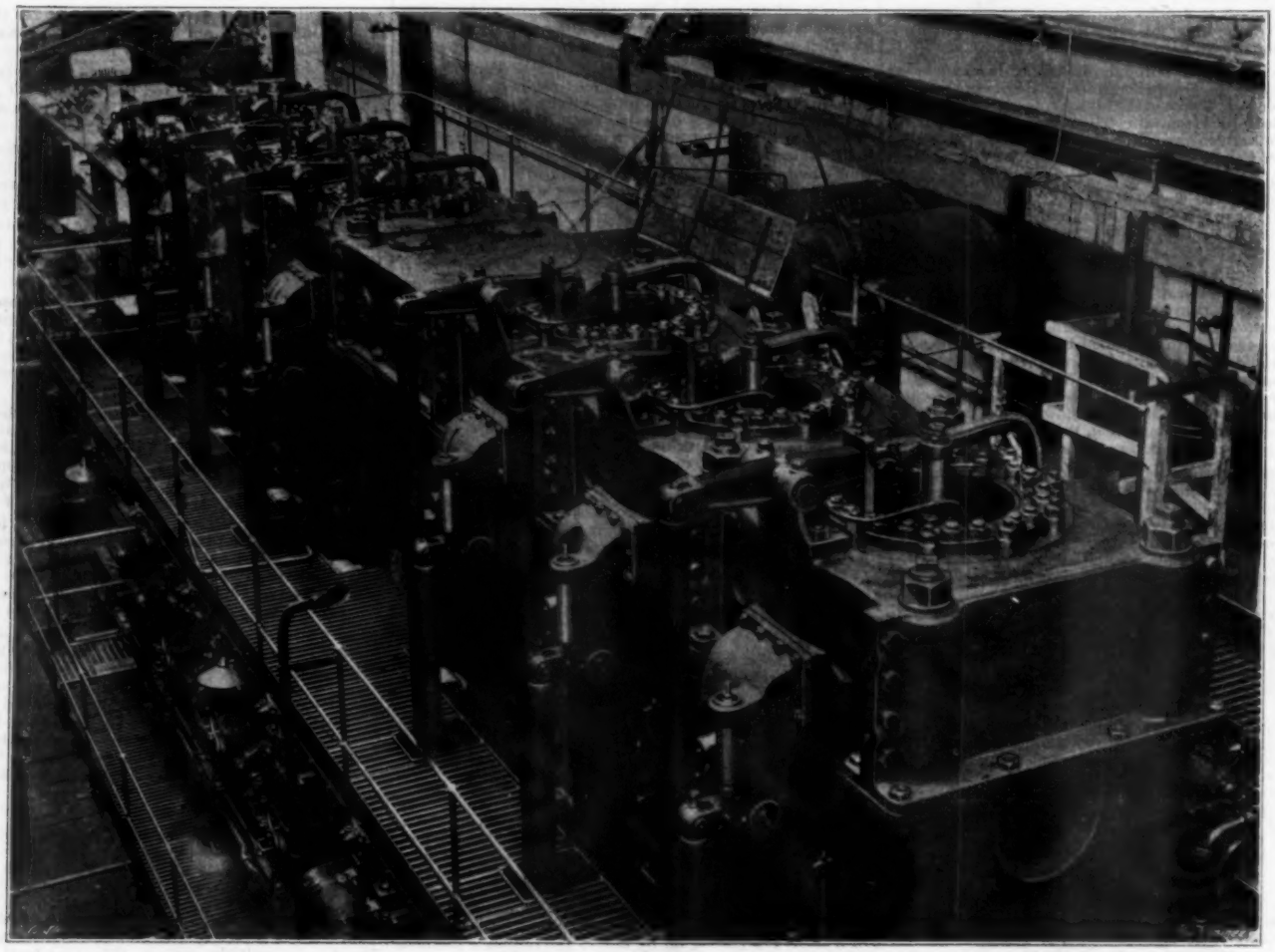
WITH the view of linking Hungary up with the international telephonic system, the Hungarian Post Office entered into negotiations with the Austrian postal authorities which have now been successfully concluded. It has been decided to lay a new cable between Budapest and Vienna, which will be finished towards the middle of 1927. When it is completed 114 simultaneous conversations with Vienna will be possible instead of seven as at present. At the same time cables between Vienna and Passau and Passau and Nuremberg are to be laid, so that the laying of the Budapest–Vienna cable will mean connection with the French, Belgian, Dutch and Scandinavian systems. Among other neighbouring States with which negotiations are in progress is Czechoslovakia, and negotiations will shortly be initiated with Yugoslavia. Only with the Rumanian postal authorities, no meetings have yet been arranged, in spite of the fact that there is no direct connection by overhead wire between Hungary and Rumania.

SOME of the London County Council's tramcars of the older classes, which are of a four-wheeled type and are mounted on a single truck, have a rocking tendency under certain conditions, and with a view to ascertaining whether it would be possible to eliminate that swaying motion, the Highways Committee a short time ago arranged for twelve cars to be fitted, as an experiment, with special suspension apparatus. Various types of apparatus were tried, and the type at present in use was experimented with during a period of over six months. The results show that the apparatus effects a very marked improvement in the steadiness and comfort of the cars, and the general arrangement is such that the wear in operation is concentrated only on detail parts of relatively substantial type and simple form, which for renewal purposes can be produced at a minimum of cost. In view of these satisfactory results, the Committee is of opinion, and has recommended to the Council, that steps should now be taken to proceed with the equipment of the remaining 188 cars of the "M" and "C" types. The average cost of dealing with that number of cars is estimated at £27 17s. 6d. a car set, the total expenditure in respect of the 188 cars being £5250. It is proposed to carry out the work of erecting the apparatus by direct employment of labour in the Tramways Department, at an estimated cost of £455, which is included in the amount of £5250.

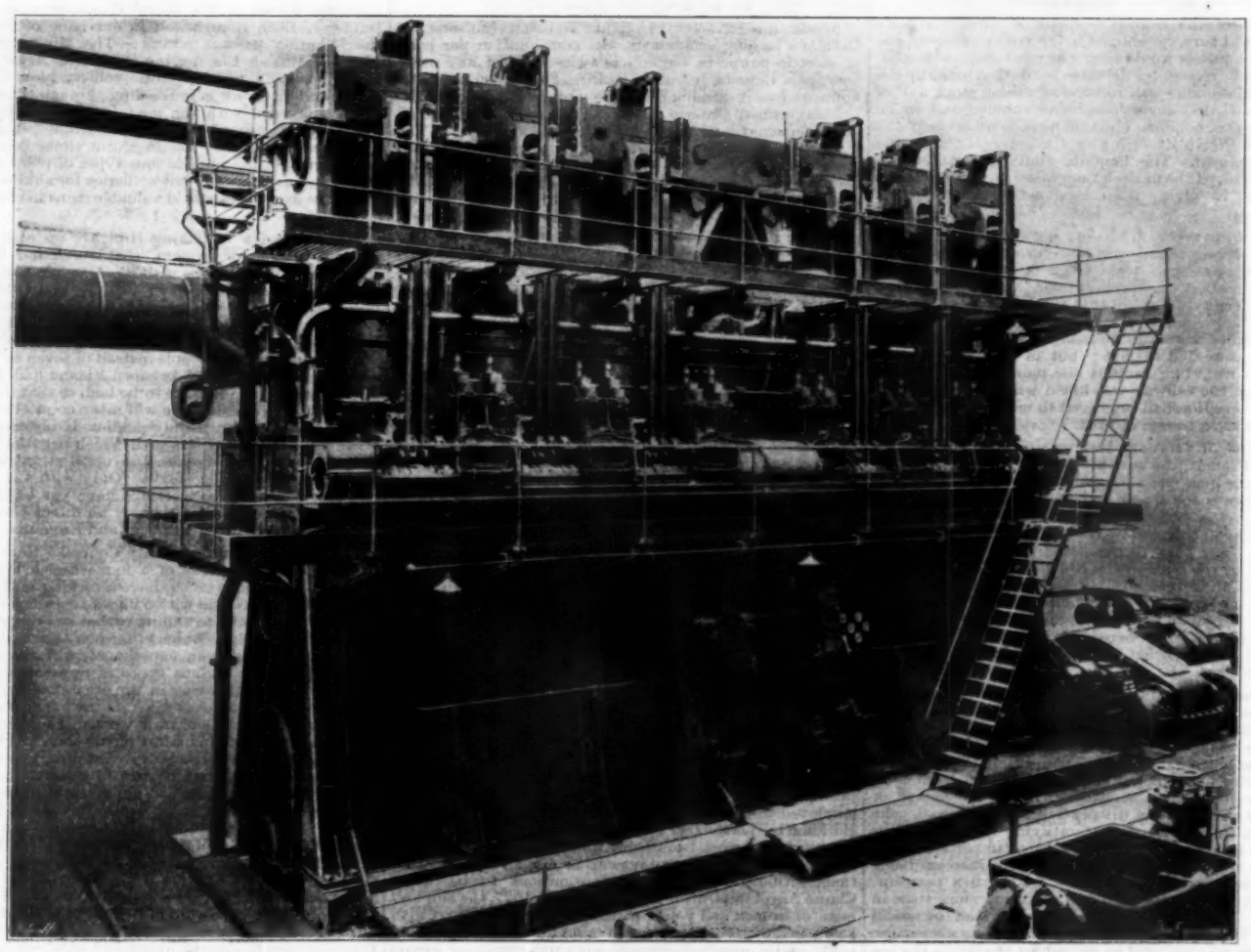
4400 B.H.P. SIX-CYLINDER DOUBLE-ACTING MARINE OIL ENGINE

MASCHINENFABRIK AUGSBURG - NURNBERG A.G., ENGINEERS

(*For description see page 353*)



TOP CYLINDER COVERS AND VALVE GEAR



GENERAL VIEW OF ENGINE AS ARRANGED ON THE TEST BED

AGENTS ABROAD FOR THE SALE OF

The Engineer

BUENOS AIRES.—MITCHELL'S BOOK STORE, 576, Cangallo.
CHINA.—KELLY AND WALSH, Limited, Shanghai and Hong Kong.
EGYPT.—CAIRO EXPRESS AGENCY, near Shepheard's Hotel, Cairo.
FRANCE.—BOYVEAU AND CHEVILLET, Rue de la Banque, Paris. CHAPELOT AND CIE., 136, Bld. St. Germain, Paris.
BELGIUM.—W. H. SMITH AND SON, 78/80, Rue du Marché-aux-Herbes, Bruxelles, and 44, Rue Joseph II., Ostend.
INDIA.—A. I. COMBRIDGE AND CO., Bombay; THACKER AND CO., Limited, Bombay; THACKER, SPINK AND CO., Calcutta.
ITALY.—MAGLIONI AND STRINI, 307, Corso, Rome; FRATELLI TREVES, Corso Umbarto 1, 174, Rome; FRATELLI BOCCA, Rome; ULRICO HOEPLI, Milan.
JAPAN.—MARUZEN CO., Tokyo and Yokohama.
AFRICA.—WM. DAWSON AND SONS, Limited, 7, Sea-street (Box 49), Capetown.
C. JUTA AND CO., Johannesburg, East London, and Grahamstown.
AUSTRALIA.—GORDON AND GOTCH, Limited, Melbourne, Sydney, Brisbane, and Perth, &c.
MELVILLE AND MULLEN, Melbourne.
ATKINSON AND CO., Gresham-street, Adelaide.
CANADA.—DAWSON, WM., AND SONS, Limited, 87, Queen-street East, Toronto.
GORDON AND GOTCH, Limited, 132, Bay-street, Toronto.
MONTREAL NEWS CO., 386–388, St. James-street, Montreal.
TORONTO NEWS CO., 42, Yonge-street, Toronto.
CEYLON.—WIJAYARTNA AND CO., Colombo.
JAMAICA.—EDUCATIONAL SUPPLY CO., Kingston.
NEW ZEALAND.—GORDON AND GOTCH, Limited, Wellington and Christchurch; UPTON AND CO., Auckland; J. WILSON CRAIG AND CO., Napier.
STRAITS SETTLEMENTS.—KELLY AND WALSH, Limited, Singapore.
UNITED STATES OF AMERICA.—INTERNATIONAL NEWS CO., 83 and 85, Duane-street, New York; SUBSCRIPTION NEWS CO., Chicago.

SUBSCRIPTIONS.

THE ENGINEER can be had, by order, from any newsagent in town or country, at the various railway stations; or it can, if preferred, be supplied direct from this office.

Half-yearly (including index number) .. £1 12s. 6d.
Yearly (including two index numbers) .. £3 5s. 0d.

If credit occur, an extra charge of two shillings and sixpence per annum will be made.

Foreign Subscriptions will be received at the rates given below. Foreign subscribers paying in advance at these rates will receive THE ENGINEER weekly and post free. Subscriptions sent by Post Office Order must be made payable to THE ENGINEER and accompanied by letter of advice to the Publisher.

THIN PAPER COPIES.		THICK PAPER COPIES.	
Half-yearly ..	£1 11s. 6d.	Half-yearly ..	£1 13s. 9d.
Yearly ..	£3 3s. 0d.	Yearly ..	£3 7s. 6d.

(The difference to cover extra postage.)

Canadian Subscriptions—
Thin paper edition .. .. £2 18s. 6d. per annum.
Thick paper edition .. £3 3s. 0d. ,,

*** READING CASES, *to hold two copies of* THE ENGINEER, *cloth sides and leather backs, can now be supplied at 4s. 9d each, 5s. 3d. post free.*

ADVERTISEMENTS.

*** The Charge for Situations Open and Wanted Advertisements of four lines and under is four shillings, and one shilling per line for each additional line up to one inch. When an advertisement measures an inch or more the charge is twelve shillings per inch. The rates for all other classes of advertisements, other than those mentioned above, are included in "THE ENGINEER Directory," which is sent post free on application. All single advertisements from the country must be accompanied by a remittance in payment. Alternate advertisements will be inserted with all practical regularity, but regularity cannot be guaranteed in any such case. All except weekly advertisements are taken subject to this condition.

Small Advertisements cannot be inserted unless delivered before TWO o'clock on Thursday afternoon (the day before publication). ALTERATIONS to STANDING ADVERTISEMENTS must arrive not later than THURSDAY of the week preceding publication.

Letters relating to Advertisements and the Publishing Department of the Paper are to be addressed to the Publisher, all other letters to be addressed to the Editor of THE ENGINEER.

THE ENGINEER DIRECTORY.

This Directory, which is published annually in the interests of advertisers in THE ENGINEER, may be obtained free of charge on application to the Publisher.

"THE METALLURGIST"—BOUND VOLUMES.

Cloth Binding Cases for twelve issues (one year) .. .. 2s. 0d.
Subscribers' own copies, including cases, bound Cloth .. 4s. 0d.
Bound half roan 7s. 6d.

A limited number of Bound Volumes of THE METALLURGIST is available, per volume 12s. 6d.; post free, 13s. 0d.

Postal Address, 33, Norfolk-street, Strand, W.C. 2.
Teleg. Address, "Engineer Newspaper, Estrand, London."
Telephone Nos. 2258, 2257 Central.

PUBLISHER'S NOTICES.

*** *With this week's number is issued a Special Sixteen-page Supplement,* THE METALLURGIST. *Every number, as issued by the Publisher, contains a copy of this Supplement, and Subscribers are requested to notify the fact should they not receive it.*

*** *If any Subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

TO CORRESPONDENTS.

*** *All letters intended for insertion in* THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

*** *We cannot undertake to return drawings or manuscripts; we must therefore request correspondents to keep copies.*

By arrangement with Reuter's Engineering Service, THE ENGINEER *contains the latest news from all parts of the world which is likely to be of interest to engineers.*

Contents.

THE ENGINEER, March 26th, 1926. PAGE

A SEVEN-DAY JOURNAL .. 341
MAIN LINE RAILWAY ELECTRIFICATION. No. XIII. (Illus.) .. 342
THE INSTITUTE OF METALS. No. III. .. 345
OBITUARY—
Sir Bradford Leslie .. 347
John Daniel .. 348
WATER POWER PROJECT IN SPAIN .. 348
INSTITUTION OF NAVAL ARCHITECTS. No. I. (Illus.) .. 349
JUNIOR INSTITUTION OF ENGINEERS .. 351
SIXTY YEARS AGO .. 351
STANDARD SPECIFICATIONS FOR PAINT MATERIALS .. 351
AMERICAN EIGHT-COUPLED LOCOMOTIVES .. 351
THE M.A.N. DOUBLE-ACTING MARINE OIL ENGINE. No. I. (Illus.) 353
ELECTRICITY IN THE HOME .. 354
RAILWAY MATTERS—NOTES AND MEMORANDA—MISCELLANEA .. 355
LEADING ARTICLES—
The Status of Naval Engineer Officers .. 357
The Railway Year .. 358
NOTES ON BRITISH RAILWAYS BY A CONTINENTAL ENGINEER. No. VIII. .. 358
BOOKS RECEIVED .. 359
INSTITUTION OF MECHANICAL ENGINEERS .. 360
AN AMERICAN PETROL-ELECTRIC RAIL CAR. (Illus.) .. 361
THE PRESENT OUTLOOK FOR BRITISH SHIPBUILDING. (Illus.) .. 362
DOUBLING THE INNER CIRCLE .. 362
LETTERS TO THE EDITOR—
Concrete Roads—Jacob Perkins' Engineering Works "To Let"—The High Efficiency Oil Engine—The British Industries Fair .. 363
HYDRAULIC CARGO CRANES ON THE MOTOR LINER ASTURIAS. (Illus.) .. 364
THE HIGH EFFICIENCY OIL ENGINE. (Illus.) .. 364
AN IMPROVED ELECTRIC FUSE. (Illus.) .. 366
WATER POWER DEVELOPMENT IN SWITZERLAND .. 366
PROVINCIAL LETTERS—
The Midlands and Staffordshire—Lancashire .. 367
Sheffield—North of England .. 368
Scotland—Wales and Adjoining Counties .. 369
CONTINENTAL PRODUCTION OF IRON .. 369
PERSONAL AND BUSINESS ANNOUNCEMENTS .. 369
CURRENT PRICES FOR METALS AND FUELS .. 370
FRENCH ENGINEERING NOTES .. 371
BRITISH PATENT SPECIFICATIONS. (Illus.) .. 371
FORTHCOMING ENGAGEMENTS .. 372
CONTRACTS .. 372

SIXTEEN-PAGE SUPPLEMENT—"THE METALLURGIST."

The Metallurgist

THE MARCH NUMBER OF THE MONTHLY METALLURGICAL SUPPLEMENT TO "THE ENGINEER" ACCOMPANIES THIS ISSUE.

THE ENGINEER.

MARCH 26, 1926.

The Status of Naval Engineer Officers.

GENERAL disappointment will be felt at the direction which the debate on the Status of Naval Engineer Officers took in the House of Commons on Monday last. The general impression which the reports of the debate leave upon the reader is that the only matter at issue is a purple stripe. Nothing could well be further from the actual fact. The purple stripe, of which Mr. Bridgeman made so much, is no more than a trifling detail in a matter of very great consequence. Engineer Officers of the "old entry" see nothing whatever derogatory in the distinguishing stripe, and if there was no more in the notorious Fleet order of November last than this narrow purple band, we should not find engineers of all kinds united in a common effort to effect the repeal of an order which they feel has debased not only the status of those engineers whose services to the Navy are of incalculable value, but of all engineers the world over. Status is an intangible thing which it is almost impossible to define, but it is wholly wrong to suppose that the wide protest against the deprivation of naval engineers of their military rank is founded in nothing greater than sentiment, and has no stronger claim to the attention of the country as a whole than a mere strip of purple ribbon.

For many years after the introduction of the steam engine into the Navy, the position of engineers was very different indeed from that of Deck Officers. The Engineer Officers of those days were little more than mechanics, and splendid as their services were, there was an inevitable social distinction which it was impossible to overlook. But in the progress of time the status of engineers in the Navy has advanced *pari passu* with that of engineers in social life, and for many years past, certainly since the introduction of the Selborne scheme in 1902, social disparity has disappeared. Moreover, the spirit of the age is entirely against social distinctions which were not only tolerated, but encouraged even so recently as the end of last century. If it be admitted, and we feel that it must be, that there is no natural separation between Executive Officers and Engineer Officers, then the only reason for giving to one a higher position in a ship than the other, can rest solely on the duties which each performs. Now it happens, as the Duke of Northumberland pointed out, when referring to this question at the opening meeting of the Institution of Naval Architects on Wednesday morning, that there are in his Majesty's ships actually more men belonging to the technical branches than to, what we may describe broadly, as the executive branches. On that ground alone, since the control of men is not the least part of the duties of naval officers, the position of Engineer Officers should not be in any degree less than that of Deck Officers. For example, it is surely a strange anomaly that under the new order the Engineer Officer will be deprived of those all too limited powers of discipline which he had the right to exercise over those under his orders, and that he has never enjoyed the respect which is shown to Deck Officers of junior rank, as, for example, in "Piping the side," which was referred to in the Memorandum by the great Institutions which was printed in our last issue. If we turn from the consideration of the relative number of men under the immediate control of Deck and Engineer Officers to the relative duties of the two, there can be no question that in a modern ship of war, if it be either a vast battleship or a humble submarine, its whole life and being, its whole power of action, its ability to do what is required of it on the instant and to achieve an object punctually and certainly, depends in the first place upon the engineering branch. In speaking thus for the profession which we are proud to serve, we should be sorry indeed if anyone imagined for one moment that we have the slightest desire to place the Engineer Officers of the Navy in a higher position than that of Deck Officers. Nothing is further from our thoughts, and we speak with confidence when we say that nothing is further from the thoughts of those Naval Engineer Officers who feel most sorely the degradation which they have suffered by this recent Fleet order. We believe that they recognise that the control of a ship as a whole, and the control of a Fleet even more than that of any unit of it, is something greater than the control of the mechanism which impels that ship or that Fleet. In time of action they take their orders willingly from the officers in executive command, and we believe that but few of them, if any, desire to see the quarter deck once more open to them. They are content to serve, where they know they can serve nobly—in the engine-room. In course of time they will be proud of the purple stripe which indicates that they belong to that branch of our first line of defence which is without superior and without equal. With such absolute equality as we have indicated, they are not concerned. What they do ask is that they should not be robbed of a rank which itself commands respect, and that they should not be put into a position before the men who serve directly under them, which is both invidious and derogatory. Speaking at the dinner of the Institution of Naval Architects on Wednesday evening, Sir William Ellis asked: "In view of the magnificent service to the country by naval engineer officers in the war, how could the country be so ungrateful as to allow the recent blow to their prestige and status to go unchallenged? How could their brother officers of the executive, with any feeling of comradeship, countenance the discrimination in social rank that the engineer officers considered the recent Admiralty decision conveyed? Further, how was it possible for naval engineers to command the respect of their staffs that should be shown to them in view of their great responsibilities if they had the knowledge, which was inevitable, of a distinction in social position and status between the executive officers and their own superior officers?"

The matter cannot be allowed to rest in its present position. Mr. Bridgeman, as we have said, has lightly turned the matter off by seizing upon an insignificant detail and by assuring the House of Commons that Naval Engineer Officers have lost nothing by the Fleet order. On this matter we may trust the Engineer Officers to know even better than Mr. Bridgeman himself. They are convinced that the Fleet order deprived them of something that they valued, of something that they had won by sheer merit, and something that placed them in a better position with regard to the *personnel* of ships of war. Nothing that Mr. Bridgeman, or that the Naval Officers who spoke in support of his views, can say will convince naval engineers, and, we may add, their brothers in the civil profession of engineering, that the Fleet order was not a retrograde step. It took years of fighting by engineers, with the late Mr. D. B. Morison at their head, to secure that recognition of naval engineers which they have so fully merited. What was won after years of endeavour is not to be lightly sacrificed, and we urge all engineers, howsoever humble their positions may be, to lend their

assistance to the Committee of the great Institutions which has taken this matter up, so that the admirable efforts which it has already made may be brought to a happy and successful issue.

The Railway Year.

THE respective chairmen of the four grouped railway companies, with the exception of Brigadier-General the Hon. E. Baring of the Southern, had a sad tale of last year's working to tell at the annual meetings. The Southern had a better report to make, as its railway receipts, net receipts and tonnage—despite a drop in minerals—were up. An analysis of the figures of all the companies shows, however, that the situation was not as bad as might at first sight be thought. The crux of the matter lies in the mineral traffic, wherein the four companies suffered a decrease in tonnage, compared with 1924, of 7·08 per cent. That traffic, it must, however, be remarked, is not only the lowest rated traffic on a railway, but comparatively it is the most expensive to work. Mineral trains travel more slowly than general goods trains, and so occupy the line longer and the engines and trainmen run fewer miles per hour; owing to the fact that most of the wagons that convey coal are privately owned, they require more shunting when being made up into trains; as wagons that have been used for coal are unsuitable for general merchandise, they cannot be used in common, and so trucks have to be provided exclusively for mineral traffic; and as merchandise wagons that have brought inwards traffic usually suffice for the outwards traffic, those that have been loaded with coal have to return empty. It may also be remarked that in 1924 62·59 per cent. of the total tonnage and 51·95 per cent. of the total ton-mileage related to mineral traffic. The fluctuations in general merchandise traffic are far more important. We find that whilst there was the above-named decrease of 7·08 per cent. in minerals, there was only a decrease of 5·44 per cent. in the total tonnage—a term that covers general merchandise, coal and coke, and "other minerals." In "general merchandise" the tonnage in 1925 was 1·31 per cent. less than in 1924, but 3·07 per cent. more than in 1923, whilst the receipts were practically the same as in 1924, but 3 per cent. less than in 1923. In the latter relation it must, however, be remembered that all rates were reduced in August, 1923. Despite those reductions, the receipts were 12s. per ton in 1925, 11s. 9d. in 1924, and 12s. 9·11d. in 1923. Therefore if the prosperity of the railways is to be measured—as appears reasonable—by their general merchandise traffic, the companies did as well last year as in 1924 and better than in 1923. The same comfort may be found in the passenger traffic returns. The four companies in question carried 1·48 per cent. fewer passengers in 1925 than in 1924, but workmen were included, and their journeys were 2·73 per cent. less in number. Workmen's fares, it is needless to remark, are not a source of profit, and any decrease, except that it indicates less general prosperity, represents no loss to the railways. The number of passengers, exclusive of workmen, was only 1·04 per cent. less in 1925 than in 1924, which latter year gave about the same number as 1923. So thus, again, there is little to complain of, especially as the average fare spent per passenger was 1s. 7·72d., as compared with 1s. 8·11d. in 1924 and 1s. 7·51d. in 1923.

Reviewing the railway business as a whole, and despite the drop of 7·08 per cent. in the mineral traffic, the receipts of the four companies from railway working were only 1·84 per cent. less than in 1924. What was set off by a reduction in expenditure must now be considered, and in that connection it must be remembered that certain charges incurred by operation and upkeep remain constant. The permanent way needs practically the same maintenance and renewal year by year, and a similar remark applies to the upkeep of locomotives and rolling stock. Actually, it is sound policy, if the falling off in business is apparently only temporary, to increase the quantity of repairs and renewals whilst times are slack, so as to have the full use of the road, engines, and wagons when trade is better. Another point to remember—and not a small one either—is that when business is bad the cost of living rises. That was the case last year, and under an agreement made when the railways were controlled by the Government, every rise of five points in the cost of living means an extra shilling per week for most of the staff, whether the companies can afford it or not. Judging by the cost to the London, Midland and Scottish Company of that rise in the bonus, it is safe to say that one-half of the increase of 1¾ millions in the four companies' total expenditure in 1925 was due to that item alone. A matter not mentioned by any of the chairmen, but which we consider has affected the railways' expenditure, is the great increase in the number of small consignments. Traders—thanks entirely to expeditious transit on the railway—now, more than ever, keep less stock on hand, knowing that the supply can be replaced within forty-eight hours after the dispatch to the manufacturer or wholesale house of the necessary order. In 1925 the London, Midland and Scottish Railway carried just one million more tons of general merchandise than in 1923, but Sir Guy Granet told the shareholders the other day that in the same period the number of consignments increased by eleven millions. We think that growth in what we would call the retail business of the railways also accounts for the general increase in parcels traffic. Mr. Whitelaw, at the London and North-Eastern meeting, found considerable satisfaction in that fact, and said it was one of the most promising items in that company's revenue account. We, on the other hand, if our assumption be correct, regret the apparent tendency of the small consignment business to grow. It is true, seeing that each parcel, bundle, roll, &c., pays a terminal charge by which the increased handling and clerical work is paid for, that the division of the aggregate into small lots is compensated for. The practice must, however, lead to wagons being more lightly loaded, and therefore to a less load per train. The last result would be very unfortunate, because if there is one direction more than another in which British railway officers need to effect an improvement it is in the average loading of their wagons and in the load per train. The annual Railway Returns show that the general loading of a merchandise wagon is under 3 tons, and the average loading per train is only 132.64 tons. The train loading includes mineral wagons, the average load of which is 9 tons. Another point about last year's results which appears to require explanation is that all four companies, except the Great Western, increased the number of their passenger train mileage. The aggregate increase was only small—1·37 per cent.—but the number of passengers had fallen by 1·48 per cent. Mr. Whitelaw suggested that it was due to an effort to compete with road transport. That may be so, but we rather suspect that it was due rather to competition between the railway companies. Anyway, it is a feature that the companies are watching, and Mr. Whitelaw said that it was receiving very special consideration at the present time.

The future of British railways is one that gives us no little concern. They are ably administered and ably worked, but we fear that circumstances are getting too much for the best of officers and the best of servants. The coal trade, both home and export, may never again be what it has been, whilst the inroad made by the motor vehicle into passenger and goods service is now too deep to be made good again, although it may be checked. Some relief for the latter evil may be forthcoming as a consequence of the deputations that have recently waited on the Minister of Transport and the Chancellor of the Exchequer to point out the handicap that railway companies labour under in having to pay for the high maintenance of roads, owing to their excessive use by motor vehicles, which compete with the railway. Relief for that cannot, however, come without legislation, and to obtain it is no easy or quick task. There is the further handicap that the companies may not act as general carriers by road. Could they do so, they would carry by road some of the traffic now taken by motor hauliers. The railways, again, have been disappointed that the National Wages Board last December did not give some relief to railway operating expenses by effecting a general reduction in the men's pay. Complaint as to that decision was very bitter at the London and North-Eastern meeting, but we would have it remembered that the award refusing the asked-for reduction was not only signed by the four representatives of "the users of railways," but, of greater significance, by two of the four railway general managers. In view of the latter fact, it is hardly necessary for us to point out that the average wages of railwaymen is only 67s. 4d. per week. Much now is hoped for from the fixing under the Railways Act, 1921, by the Railway Rates Tribunal of the standard rates and charges that will be operative from "the appointed day." Those charges, it must be remembered, are to be of such an amount as will guarantee to the companies a net revenue equal to that of 1913. The closing stages in the inquiry are now taking place, and the traders and other interested parties are concerned in reducing the amount of the future charges as much as possible. The obligation on the Tribunal is, however, mandatory, and the companies are secure in the fact that they are entitled to the same net revenue that they had in 1913. But it is quite clear that however low the rates may be fixed, they will be higher than to-day. That being so, is it likely that the same amount of business will be carried? We fear not; the higher rates will lose orders in some cases, whilst in others they will put more traffic on to the roads. If, then, the companies dare not raise their rates to the new scale, how are the dividends to be kept up when the compensation paid under the Act of 1921 is exhausted? The answer to the question is, to our mind, to be found in the companies improving their operations, and, above all, in reducing the congestion which now runs away with money in delay to trains, overtime for men, longer occupancy of the line, slower return of rolling stock and compensation claims for delay in transit. Quoting Mr. Whitelaw once more: "The saving in annual expenditure by the elimination of congestion will much more than meet the interest on the capital cost of carrying out our plans."

Notes on British Railways by a Continental Engineer.

No. VIII. (*Conclusion*).*

Goods and Traffic.

THE transport of merchandise is, as has been pointed out, effected by means of low-capacity wagons, and by trains the weight of which is, in general, not heavy, saving, for example, in the case of those taking coal to London. However, there is noticeable a distinct tendency to correct these errors and to employ heavier and heavier trains.

There are, as is well known, two principal and diametrically opposed methods of regarding goods traffic, it being granted that the carrying capacity is proportional to $m\,v$, where m is the weight of the train and v the speed. They are:—To effect it (a) by a large number of relatively high speed and light trains running on the main lines or on lines specially apportioned to them; or (b) by a fewer number of excessively heavy trains running on the same metals as the passenger trains. The first method is certainly the more costly, for it entails the employment of a larger number of train crews. The second method has been chosen in the United States, where single lines predominate, but to ensure the required volume of traffic, it is necessary to employ trains weighing as much as 4000 tons, and to haul them by locomotives of very great power, especially on mountain lines with heavy gradients, and sometimes even to use two and three engines.

In England, where the distances to be covered are relatively short, the towns and stations close to one another, and the population very dense, the problem has been solved by choosing the first of the two methods, but quite early it was found necessary to increase the number of tracks in busy portions of the lines. It is for that reason that on the great main lines running into London from the North and West there have for many years now been four tracks for a considerable distance from the Metropolis. In principle, two of the roads are reserved for express or fast trains, though the latter can also use the other roads which are particularly intended for goods trains. This method is entirely opposed to that employed in the Middle West and West of the United States, but it also has its limitations, and an appreciable increase in traffic might result there, as elsewhere, from a general increase in the weight of the trains and the power of the engines, and that is just what is beginning to happen. In any event, the provision of four roads, which will continue to be the practice, affords great facilities. As a matter of fact, the doubling of the roads has become necessary in the outskirts of Paris, but the widened lines do not extend, at present, to a greater distance than from 30 to 35 miles. But many lines have been doubled.

However that may be, the system of using frequent but relatively light trains is not cheap, for a light train requires just as many men to work it as does a heavy train. The economic position, which is becoming more and more strained, is compelling the English railways to seek new solutions of the problem, for those which were eminently serviceable twenty years ago do not meet the existing conditions. There is also the question of the strength of the couplings, and powerful locomotives are employed to push trains on inclines.

Management.

Everything is, as has already been remarked, much more simple in England than in France or Germany, for example, because of the liberty which the companies enjoy, of the small extent to which the

* No. VII. appeared March 19th.

State interferes in minor details, and because of the comparatively short lengths of the lines. Furthermore, they are founded on a really industrial and much less administrative basis, in spite of the modifications which have been the outcome of the world war.

This simplification finds its counterpart in the general management of the companies, which is even less complicated than in the United States, though a new country. It is true that certain systems have, as the result of recent changes, attained very large dimensions, which call for a corresponding increase in managerial staff.

The problems of *personnel* and many other matters must from now onwards assume a degree of importance which was formerly unknown, although for many reasons, insular isolation in particular, the simplicity of the conditions in England will remain much greater than it is elsewhere.

It has always appeared to the writer that the reason why there are fewer subalterns and staff officers doing sedentary work in British railway offices than in those of the other railways in Europe, is not because the amount of work done per person is greater, but because they have to do so much less accessory work —such as furnish reports to ministers, to directors, and to the management ; work out calculations concerning coal premiums and other things ; and deal with technical matters, involved litigation, tariffs, travel permits, &c., which require whole offices. These questions are all dealt with very much more simply in England.

It may be added that the Board of Directors is not entirely composed of financiers and that their attention is not solely confined to questions of finance. It appoints technical committees which exercise their power or their supervision over all branches, without, however, interfering with the special responsibilities of the various officers.

Conclusions.

The writer has now examined, as a whole, the matters which it seems to him best bring out the characteristics of the British railways, and he has adduced several comparisons, with the object of showing the methods employed in higher relief, at the same time explaining why they are not all used abroad, although many of them might be introduced there with advantage.

It is all the more necessary to insist on certain points because one is far from being struck with them at first sight—as in the United States, for example—by the extent of the station, the size of rolling stock, or the hugeness of the engines, all of which are likely specially to impress the visitor naturally inclined to be impressed by big things. The stranger, however, will soon realise that he is face to face with an organisation that is quite different from anything to which he has been accustomed, and does not pretend to be like it, and the general composition of which forms one homogeneous and uniform whole, that will be recognised as being perhaps unequalled in efficiency if, instead of concentrating attention on certain special services, he takes in review the country as a whole and its normal train services of all classes.

Nevertheless, largeness is far from being absent from the whole, and nowhere can be found equal areas so covered with railways in active operation, and with so many junctions and sidings, not only in the neighbourhood of London but round all the large towns in the country.

The points which specially distinguish the British railways are : The homogeneous whole which they present ; the small difference between the management of the main and secondary lines, which is much less than it is abroad, and the comparative absence of provincial districts ; the high receipts per mile ; the neatness which characterises everything, and the excellent condition in which everything is kept. One feels that the railways are really made for the public, even for the most modestly circumstanced. The multiplicity of trains and the facilities which are accorded to the traveller are the result of private initiative, and of the liberty enjoyed by the companies in an over-populated and highly industrialised country, certain parts of which are, so to speak, only a succession of important towns and of works or mines. The great volume of the traffic allows of a coefficient of working which is higher than it is anywhere else, but which, instead of being hampered by a complicated administration, makes itself felt by producing tangible and practical results. It is all this that must be carefully examined and understood, but which at first glance escapes the untrained eye.

The British railways are in the first place remarkable for the generally excellent character of their permanent ways which is unique ; for the extent to which the block system has been applied ; for the facilities for intercommunicating between various systems which exist in so many stations and in all directions ; and for the generalisation of modern bogie rolling-stock. This initiative, which the tendencies of to-day do less and less to help, combines to give to the English railways—if we overlook the restricted and unfavourable loading gauge—their up-to-date and finished appearance. Not to speak of the United States, the French railways can compete very successfully with the British railways in that which concerns the main lines and the express or *de luxe* trains, which are wider and often much heavier, but it seems to the writer permissible to consider that Great Britain will long continue to be the country of the "highest all-round average," especially if the State does not interfere with the management of its railways more than it has done in the past.

More reserve must be maintained regarding the manner in which the goods services have been carried on, not, be it said, as regards the efficiency and rapidity of delivery, but on the score of economical operation. Great changes are at present being made in the direction of running heavier trains.

It must not be lost sight of that the United Kingdom does not, for many reasons which have been referred to, suffer from many of those obstacles which are met with elsewhere. Great credit must be given to the French railways, for example, for the immense and remarkable efforts which have been made since the war, in the face of difficulties of which a foreigner could have no conception, and for the complete reconditioning of one portion of the system of the Nord and Est Companies which had been torn up and entirely destroyed by the enemy ; and the reconstruction of important stations which had been reduced to ruins, of blown-up tunnels, of thousands of damaged bridges, and of workshops razed to the ground. In this direction admirable efforts, about which much too little is known, have been made.

For reasons set out above the continental rolling stock has undergone important remodellings, which began to manifest themselves some fifteen years ago, and which even the war could not entirely interrupt. In France nowadays there is a large number of locomotives which, on the score of power, are only beaten by the American engines. But Great Britain could for many years do good service without such engines, thanks to the number of trains and to the excellence of the fuel available, but the evolution towards large engines is very conspicuous now. The time has undoubtedly come when it will be necessary to operate more economically—that is to say, employ heavier trains and more powerful locomotives, but then the question of braking goods trains will have to be tackled. However that may be, England, which is able to scrap its rolling stock more quickly and which knows little of thinly populated and of purely agricultural districts, has seen disappear, in large measure most secondary lines, the engines, even those which have been rebuilt and which suffice even now on the Continent for branch lines, and more quickly still, rolling stock not fitted with bogies.

It must be acknowledged that British superintendents, when designing new and powerful types of engines, have not lost sight of the traditions and have produced locomotives as neat and of as good appearance as formerly. No better example can be given than to refer to the Mikado engines of the London and North-Eastern Railway.

Personally, the writer considers that the railway is perhaps, for those who know it well, the British industry *par excellence* ; the industry with which the country has obtained the best results, and for which she has the greatest innate taste, except perhaps her mercantile marine. Thirty years ago Great Britain had everything her own way and was in advance of other countries as regarded the quality of her permanent ways, organisation, signalling and speed. She has lost her superiority with regard to the last, which others, but only French and American companies, share with her in connection with their important fast trains, but she undoubtedly still retains her superiority in the first two directions, and will certainly continue to do so for a long time to come.

The Traffic Department requires more from the average train—notably on branch lines—and has established closely timed services throughout the United Kingdom, which compel the drivers to see to it that they do not lose a minute. It is only necessary, in order to become convinced of that fact, to see with what rapidity they obey the signals of the guards and the smartness with which they get the trains away.

The thing which most specially distinguishes the British railways is the neatness and tidiness which is everywhere observable, and the excellent state of repair in which everything is kept, even in the most remote districts, and it is quite evident that the efforts of all the companies are concentrated in ensuring that a uniform standard of maintenance is kept up.

There is, in the organisation of the British railways, something which is so efficient that the considerations which have been alluded to do not entirely account for it. The simple and well regulated conduct of the large termini persists, even at times when additional services are being run and when there are the greatest crowds. At such times the service is carried out without bustle and in perfect order. It is especially in this direction that the continental railways have still something to learn ; from the point of view of the actual working of the trains they are far from being behind, saving in the speed of shunting and marshalling.

We will take as an example a large terminus in Paris, which has more than twenty platforms and which dispatches normally as many trains as any terminus in London, but in which the service is carried out with some difficulty on "rush" days, in spite of the numbers of station officials, which represent an organism practically unknown at English stations. It is quite clear that low and narrow platforms are not suitable for dealing quickly with more than a limited number of passengers, and that in consequence of local customs or of laws, the baggage service is complex. Perhaps the English middle classes travel less than abroad, but it has also to be remembered that Paris, for example, has only nine termini, whereas London has at least fourteen, without counting a number of important stations which, though not in the suburbs, are not in the central parts of the city.

I am far from contending that the English railways could not, to complete their organisation and equipment—even if electrification were left out of consideration—gain useful inspiration from innovations and convenient arrangements which have been adopted on the Continent and in the United States of America. Their organisation is sufficiently remarkable for it to be permissible to suggest several modifications which would result in more economic working. They have already taken steps towards using heavier trains and more powerful engines, differing in type from the classic models, but they must continue to avoid formalism and bureaucracy and retain the industrial enterprises the silent, and so to speak, automatic activity of which maintains their powerful originality.

To sum up, if one takes the position of a normal traveller, especially a passenger with a third-class ticket, the British railways offer a homogeneity, and a general excellence, which every impartial stranger, who is not imbued with preconceived ideas, must acknowledge, whether it be as concerns the permanent way, the signalling arrangements, the absence of crowding, the good up-to-date rolling stock, the rapidity of train movements, or the multitude of facilities placed at the disposition of the public. America can show a colossal provision of rolling stock which is admirable and unique by reason of its dimensions, and which is eminently suited to the requirements of a country of long railway journeys, but which does not always offer the special comfort and privacy required by the European. It is not, of course, the outside dimensions of a vehicle which ensure the comfort of which we are speaking.

From the point of view of goods traffic, on the other hand, England must to a greater extent correct and is actually correcting her long standing ways, not because her methods do not give satisfaction, but because they do not fall into line with modern economic conditions.

Such have been, in Great Britain, the results of a continuity of views, and of a persistency of ideas, which have lasted for three-quarters of a century, upon a simple and effective organisation, results which have been greatly helped by the assistance, long ago assured, of devoted and disciplined servants. From this point of view the maintenance of British tradition *is more than ever necessary*, and, saving for the few points which have been mentioned, and with conditions as they are at present, one can only trust that the traditions and the spirit of those who have hitherto ensured the prosperity of good service on the railways of the United Kingdom will be perpetuated.

BOOKS RECEIVED.

Die Entwicklung der Dieselmaschine. By Professor R. Schöttler. Halle (Saale) : Wilhelm Knapp. Price 3 Mk.

Profit Sharing : An Aid to Trade Revival. By M. E. Askwith. London : Duncan Scott, Ltd., Bush House, W.C. 2.

Cours de Thermodynamique. By G. Bruhat. Paris : Masson et Cie., 120, Boulevard Saint Germain (VI^e.), Price 40 fr. net.

The Way to the Smokeless City. By W. H. Casmey and Sir E. Hoyle, Bart. London : Charles Griffin and Co., Ltd., 42, Drury-lane, W.C. 2.

Sell's Directory of Registered Telegraphic Addresses, 1926. London : Business Directories, Ltd., 8, Johnson's-court, E.C. 4. Price 45s. net.

Transactions of the Institution of Engineers, Australia. Vol. IV. 1923. Sydney : The Institution of Engineers, Australia, 16, College-street, N.S.W. 1.

Hydraulics : Gauging of Sewage Flows, &c. By T. Barlow. London : Crosby Lockwood and Son, 7, Stationers' Hall-court, E.C. 4. Price 6s. net.

The Economics of Carburetting and Manifolding. By R. W. A. Brewer. London : Crosby Lockwood and Son, Stationers' Hall-court, E.C. 4. Price 12s. 6d. net.

Military Engineering. Volume I. *Mechanical Engineering.* London : His Majesty's Stationery Office, Adastral House, Kingsway, W.C. 2. Price 3s. 6d. net.

The Principles of Electric Power Transmission and Distribution. By L. F. Woodruff. London : Chapman and Hall, Ltd., 11, Henrietta-street, W.C. 2. Price 20s. net.

A Dictionary of Applied Chemistry. Volume VI. *S. Acid —Tetryl.* By Sir Edward Thorpe. London : Longmans, Green and Co., Ltd., 39, Paternoster-row, E.C. 4. Price £3 net.

Specification. For Architects, Surveyors, Civil Engineers and all interested in Building. Edited by F. Chatterton. London : The Architectural Press, 9, Queen Anne's-gate, S.W. 1. Price 10s. 6d. net.

Institution of Mechanical Engineers.

THE HIGH EFFICIENCY OIL ENGINE.

LAST Friday evening, at a well-attended meeting in London of the Institution of Mechanical Engineers, Mr. A. E. L. Chorlton presented an interesting, practical paper on "The High Efficiency Oil Engine." In the course of his paper, a reprint of which is begun elsewhere in this issue, Mr. Chorlton examined the general situation of the present-day internal combustion oil engine with regard to efficiency and what possibilities existed for improving that factor. As a result of his examination he suggested that from the thermal point of view the most promising line of development seemed to be offered by an engine working on the explosion—or constant volume—cycle, with comparatively high maximum pressures, employing self-ignition by means of the compression temperature and using fluid pressure for the injection of the fuel. In addition, he concluded that a higher mechanical efficiency might be expected than that realised in the normal "Diesel" engine. The conditions required to be fulfilled in order to realise the advance outlined could, Mr. Chorlton said, be successfully met by an engine running at an increased speed—revolutions per minute—using forced lubrication and operating on low cost fuel oil. The consumption of such an engine would be of the order of 0.36 lb. per brake horse-power hour. Mr. Chorlton concluded his paper with a brief description of the design and construction of an actual engine to fulfil the conditions he had specified and gave some practical test results that had been obtained with it.

In discussing the application of the engine referred to to railway work, Mr. Chorlton gave some interesting figures for the fuel consumptions of ordinary coal-fired locomotives as compared with that of a Beardmore-engined rail car. The figures set out in tabular form were as follows :—

Fuel Consumptions.

Great Western Railway tests	3·93 lb. coal per D.B.H.P. per hr.
L. and Y. Railway tests ..	3·78–4·69 lb. " "
Pennsylvannia R.R. tests	4·42–6·76 lb. " "
I.C.E., Beardmore, rail car	0·38 lb. oil per B.H.P. hr.

Fuel Costs.

Cost per D.B.H.P. hr., with coal at 27s. 6d. per ton, 4·0 lb.	= 0·59d.
Cost per B.H.P. hr., with oil at £4 per ton, 0·38 lb.	= 0·16d.

Mr. W. A. Tookey, opening the discussion, remarked that to obtain increased efficiency in oil engines Mr. Chorlton had shown that we could proceed in three different ways, namely, by increasing the volume ratio, by using higher piston speeds, and by employing higher mean pressures. Mr. Tookey proceeded to analyse the subject in the light thrown upon it by a large collection of test results obtained on engines of all classes and sizes as set out on a basis of mixture strength. The gist of Mr. Tookey's discussion will, we understand, be given in full in a paper which he is to present on April 9th before the Diesel Engine Users' Association. His deductions gave general support to Mr. Chorlton's arguments. He suggested that with a volume ratio of 20 to 1 a thermal efficieney of 55 per cent. might be reached, and that increased piston speed would also result in an improved efficiency. His investigation showed, however, that there was a limiting mixture strength which should not be exceeded. With mixture strengths of from 10 to 80 B.Th.U. per cubic foot of total eylinder volume there was, he said, a general rise in the amount of heat converted into work, but with mixtures stronger than 80 the extra heat was not converted into work, but passed away in the exhaust. Mr. Tookey also showed that in engines of the crank case compression type the promise of higher efficiencies was not so great as in engines possessing a better scavenging system. Greater mean pressures, he added, were essential to advance.

Mr. D. R. Pye said that Mr. Chorlton had advanced an argument in favour of increasing the compression ratio and of raising the maximum pressure. All the experiments which Mr. Chorlton quoted in support of his argument, such as Ricardo's, Burstall's, and Sparrow's, were conducted on engines in which the mixture was compressed. As the compression pressure was raised a point was approached beyond which it was impossible to compress the mixture without causing it to ignite, and resort had to be had to the Diesel principle of compressing the air alone and injecting the fuel into it. At and beyond this limiting value of the compression ratio the whole problem considered by Mr. Chorlton assumed a changed aspect. The problem, said Mr. Pye, became one of securing the satisfactory combustion of the fuel injected into the compressed air. With compression ratios above 12 to 1, especially in cylinders of small size, great difficulties would be experienced in obtaining satisfactory combustion, for the combustion space would assume a very awkward form. Did Mr. Chorlton advocate the use of very high maximum pressures in conjunction with increased compression ratios? He, Mr. Pye, expressed the belief that the advantages of such a course would be countered by its disadvantages. Mr. Chorlton argued that the mechanical efficiency would not be affected by increase in the compression ratio. Against that view it should be noted, Mr. Pye concluded, that Ricardo's experiments with an engine having a series of interchangeable cylinder heads which gave a range of compression ratios from 5 to 1 up to 12 to 1 showed that the mechanical efficieney suffered considerable diminution as the compression ratio was increased.

Mr. W. J. Stern remarked that the mechanical losses of an engine under load were difficult to determine with accuracy, for they were dependent upon the measurement of the indicated horse-power. At the Air Ministry Laboratory careful tests had been made, and with a compression ratio of 7 to 1 it was concluded that the mechanical losses had increased, but not sufficiently so to overshadow the gain in efficiency. He believed, however, that increased compression ratios would reduce the life of the engine. In Diesel engines, he remarked, a 15 to 1 compression ratio was, he understood, the highest value that was found to pay.

Eng.-Captain G. W. Phillips remarked that while it was possible to increase the compression ratio up to and beyond 15 to 1, it was important to remember that simultaneously the ratio of the maximum to the mean pressure would also be increased, and therefore that the weight of the engine per horse-power of its output would be raised. On the whole, from the practical point of view, one would lose on the deal. Mr. Chorlton, he continued, had not discussed the effect of the jacket temperature on the efficiency of an engine. Ricardo, in his analysis of the mechanical efficiency of Diesel engines, had found that a rise in the jacket temperature considerably reduced the mechanical losses by reason of the reduction it effected in the viscosity of the lubricating oil between the pistons and the cylinder walls. The Still engine, Captain Phillips remarked, might be found to possess a marked advantage in this respect by reason of its high jacket temperature. No mention, too, was made in the paper regarding capital charges. Such charges could not be put on one side, although they, together with the weight per unit of power, were items which Diesel engine makers frequently forgot to discuss.

Mr. F. H. Livens agreed with Mr. Chorlton's remark that the first internal combustion engine in which air was compressed and the fuel driven into it was produced in this country. It was made and patented by Ackroyd. He, however, did not carry the compresion of the air to the point of self-ignition, and in that respect was undoubtedly surpassed by Dr. Diesel. In his original patent Diesel appeared to believe that the fuel would burn as it was admitted into the compressed air and that the flat-topped or constant pressure diagram so obtained was the most satisfactory form. It was now generally accepted that the sharp pointed or constant volume diagram was the best, although it was difficult to understand why it should be so. He liked to see a diagram with plenty of width about it. In the sharp-pointed diagram the maximum pressure occurred when the crank was on the dead centre, and was therefore exerted against zero leverage. That fact, he thought, would at least delay the extension of the initial pressure to the high values that had been suggested. On the subject of turbulence he remarked that in an engine making 250 cycles per minute about ¼ second was available for each cycle of ignition, expansion, exhaust, suction, and compression. In that fact sufficient cause for turbulence was to be found, no matter what was the shape of the combustion chamber. The main function of the neck in the "Lincolnshire" globe form of combustion chamber was not to cause turbulence, but to heat up the air drawn into the cylinder and during its period of compression just before the injection of the fuel. One of the greatest problems of the subject was to endow the fuel with the necessary penetrating power to cause it to become properly mixed with the heated mass of air. As regarded increase of speed, it was to be remembered that if the piston speed were increased from 900ft. per minute to 2700, the inertia forces would be increased in the ratio of 9 to 1. How were those forces to be dealt with in large engines? The constructive materials at our disposal were such as to impose on us a cautious, step-by-step advance. If the initial pressure were increased especial care would require to be taken with the increased pressure thrown on the engine bearings. Altogether while it might be possible to realise a gain in efficiency of 5 to 10 per cent. by the methods which Mr. Chorlton had indicated, the second 5 or 10 per cent. would, he believed, involve very great difficulty.

Mr. H. Sammons expressed doubts as to the general applicability of Mr. Chorlton's deductions. The cylinders of the engine described in the paper had, he said, a bore of 8¼in. and a stroke of 12in. He did not believe that equally high compression ratios could be employed in an engine with bores of 3½in. to 4in., for the compression space required would be so small that the combustion of the fuel would be inefficient. Mr. Chorlton's paper showed that the steam engine was, or could become, a serious competitor with the oil engine in the matter of efficiency. He himself believed that the high-speed, small-bore Diesel type engine was going to be a serious competitor with the petrol engine as now made. Consumptions of 0·4 lb. per brake horse-power per hour had already been realised with such engines when using a distillate fuel costing only half the price of petrol.

Engineer-Lieut. G. W. B. Hext gave some details of the results achieved with a solid injection Diesel engine designed in conjunction with the Admiralty Engineering Laboratory and produced at one of the Royal Dockyards. The engine ran at 300 revolutions per minute and at full power had a compression pressure of 480 lb. and a maximum firing pressure of 630 lb. Its consumption worked out at 0·387 lb. per brake horse-power per hour and the mechanical efficiency was determined at 84 per cent. At the peak of the diagram constant pressure conditions were just visible, the peak assuming the form of a hairpin 1 mm. wide, that was to say, $^1/_{42}$ of the total length of the diagram. One of the six cylinders, for some reason not stated, gave an exceptional diagram, in which a sharp peak replaced the hairpin bend and in which the maximum pressure rose to 700–750 lb. This cylinder was running apparently under constant volume conditions, yet its mean indicated pressure, in spite of the considerable increase in the firing pressure, was practically the same as that of the five other cylinders, the pressures being 71 lb. and 70 lb. respectively.

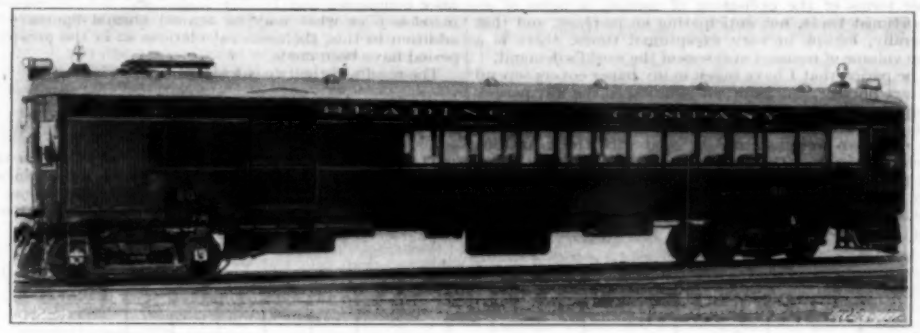
Dr. H. S. Hele-Shaw called attention to the important part which lubrication played in the running of internal combustion engines. Quoting a report issued by the Diesel Engine Users' Association, in which the running costs of about forty Diesel engines of all sizes at home and abroad were summarised, he said that the relative average figures worked out as follows :—Fuel, 0·393; lubricating oil, 0·078; water, 0·007; stores, 0·011; wages, 0·148; repairs and maintenance, 0·141; total, 0·776. It would be seen, he said, that lubrication cost more than a tenth of the total running expenses. In some cases the oil after being used was sold for fuel at 2d. per gallon merely to get rid of it. Yet effective filtration methods now existed by which the oil after use could be recovered actually in a better condition than that in which it was first supplied.

Mr. Chorlton, in his reply to the discussion, said that he was aiming more at high maximum pressures than at high compression ratios. Compression ratios of 12 to 1 had to be reached to get self-ignition and ratios of 14, 15, and 16 to 1 could conveniently be used. But even with a 12 to 1 ratio a much higher maximum pressure could be employed with advantage than was usual. He would grant that by so doing one would not obtain materially higher mean indicated pressures. He did not advocate higher mean pressures, but was chiefly concerned with improving the efficiency, taking into account the mechanical construction of the engine. The object he was concerned with in the paper was the design and construction of an engine to fulfil the given conditions and not merely to vary the compression ratio, as Ricardo had done in his tests, by changing the cylinder head of an existing type. Dealing with the question of lubrication, he called attention to the fact that according to Dr. Stanton the lubrication between the piston rings and the cylinder walls of an internal combustion engine was of the "boundary" type. Just before the meeting began, he continued, he had received a telegram from Dr. Mellanby at Glasgow giving the results of a test just completed on a Parkhead engine. During this test the engine developed 263 horse-power and consumed 0·35 lb. of fuel per brake horse-power hour. Regarding the effect of the cooling water temperature, he referred to the second test mentioned in Table VII. of the paper, in which the brake horse-power was 172, the inlet temperature of the water 120 deg. Fah., the outlet temperature 128 deg. Fah., and the fuel consumption 0·385 lb. per brake horse-power hour. In another test, he said, with an inlet temperature of 176 deg. Fah. and an outlet temperature of 200 deg. Fah. the fuel consumption was 0·324 lb. for an output of 219 brake horse-power. The cooling effect of the water was, it could be deduced from these figures, better when the outlet water was approaching the boiling point than when it was at a lower temperature. Possibly, too, the high outlet temperature aided the combustion of the fuel. As regarded cylinder sizes, he agreed that it was difficult to obtain satisfactory combustion in cylinders of 3½in. to 4in. bore. At present 6in. cylinders were about the smallest that would give satisfaction. Dealing with the latest Admiralty design of engine, he remarked that a mean pressure of 70 lb. was good. In the Beardmore engine a mean pressure of 120 lb. had been obtained during some of the tests, but the economy was not satisfactory, and on the whole he thought that a pressure just over 70 lb. was the most economical. Filtration of the lubricating oil with an improvement in its properties was a very important practical point. Ordinary centrifugal methods of treating the oil were, he concluded, not good enough for the purpose.

CONSIDERABLE additions have been made to the Southern Railway Station at Queen-street, Exeter, to allow for the more ready joining up of the separate portions from Plymouth, North Cornwall, and North Devon into one train for London. The up platform has been extended some 600ft. and made 1270ft. long. A scissors cross-over has been laid in between the up through and the up platform lines, which permits two portions simultaneously to use the up main platform line. The connections to and from the goods yard have also been remodelled, and Exeter yard is now protected by two signal-boxes instead of by three. The reconstructed terminal station at Exmouth has two platforms, 25ft. wide and 600ft. long, and four platform roads.

An American Petrol-Electric Rail Car.

INCREASING cost of operation and reduced revenue are forcing the railways the world over to test the economy of all available methods of transportation. Some have adopted electrification with its ability to handle congested traffic; others, some form of self-contained unit suitable for services on which heavy trains are not required. Savings in labour, maintenance and fuel make the self-contained unit most suitable for branch line service and main line local service.



PETROL-ELECTRIC RAIL CAR

Various types of self-contained or self-propelled units have been developed and tried in the United States during the past twenty-five years. The petrol engine outranks the Diesel engine in the number of applications to railway service in that country, for several reasons, among them being its lower cost and lower weight. Several forms of transmission have been tried with each of these types of prime mover, but the reliability, flexibility, &c., of electric transmission has brought it to the forefront.

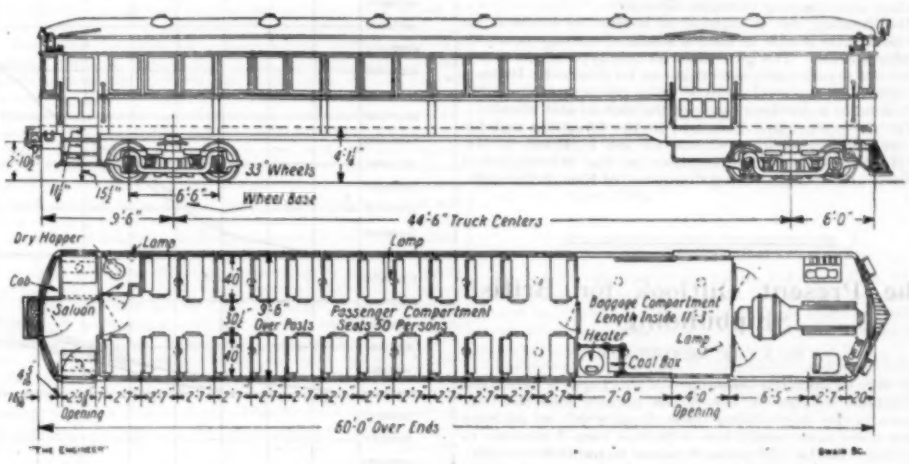
A typical example of an American petrol-electric car is that which is now in service on the Trenton Branch of the Reading Railroad. This car has, since it began to operate, been run approximately 16,000 miles. It works between Trenton and the main line connection of that branch of the Reading with New York–Philadelphia trains at Trenton Junction. The total run is 3·7 miles. The service is unusually severe as four station stops are made, and operation at times is with a standard trailer, while there are gradients up to 1·1 per cent.

The average schedule time for the one way trip—Trenton to Trenton Junction—is ten minutes. The stops at each terminus are from 4 to 10 minutes in duration, so that a minimum round trip occupies 24 minutes. Without these terminal stops the average schedule speed is 22 miles per hour. A total of twenty-one round trips is made each weekday, and there are twenty-three on Saturdays, which gives an average daily mileage of 170. A 110,000 lb. standard steel trailer coach is hauled on three of the round trips. This car also handles the shunting of express cars at Trenton and the transferring of one 73-ton express car from Trenton to a main line train at the Junction. This one car has replaced two class Q–1, 2–6–4 type steam locomotives and one coach. The locomotives were of special design for operation in either direction, and in normal service run around the cars as the stops at each terminus were not long enough to allow for turning on a wye. For normal operation of the car no extra movement is necessary, as the control is arranged for operation from the rear end, and unless a trailer is hauled the operator can run the car from that end.

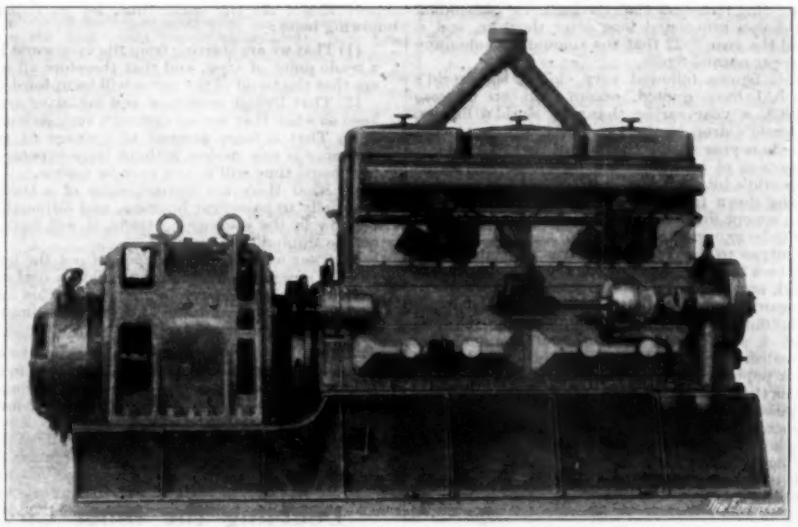
The weight of the car without load, but with all necessary equipment, is 90,000 lb. For operating weight, approximately 10,000 lb. should be added for the average live load. The car body is of steel and has straight sides, round ends, and an arched roof. The under frame comprises a centre sill of two 12in. channels on which the engine generator is mounted longitudinally. Heavy cross members riveted to the centre sill support the car body frame. The car body is 60ft. long over the end sills and 9ft. 6in. wide over the posts. The height from the floor to the roof of the car is 7ft. 10in., and the overall height is 12ft. 3½in. The engine-room, which is 10ft. 8in. long, contains a petrol engine generator unit and the control apparatus. There is a baggage compartment which is 11ft. long and 9ft. wide, which gives a floor area of almost 100 square feet, of which about 16 square feet is occupied by a hot water heater. The main portion of the car is a passenger compartment which is 35ft. 10in. long and has seats for fifty passengers. The seats are of dark brown imitation leather, 40in. long, and are spaced 2ft. 7in. apart. Steel partitions, with a swing-type door, separate the engine-room from the baggage room and the baggage room from the passenger compartment.

The four-wheeled bogie trucks have a fixed wheel base of 6ft. 6in., with 33in. wheels, and are spaced 44ft. 6in. between centres. The front pair under the engine generator set support approximately 60 per cent. of the car weight. The long wheel base and truck centre distance, and the extra heavy trucks used were chosen to give good riding qualities, which are added to by the steel construction used in the under frame, posts and side sheeting.

The motive power equipment of the car consists of a petrol engine-driven generator, two motors, and control apparatus for reversing the direction of the car and controlling its speed. All the units were designed with the idea of obtaining simplicity, reliability, and economy in operation. The car weight and service dictated that an engine capable of delivering 250 horse-power should be used, and that the electrical equipment should be capable of utilising the total engine power.



ARRANGEMENT OF THE RAIL CAR



PETROL-ELECTRIC GENERATOR

The engine power output having been determined from the car weight and service conditions to be met, a petrol engine capable of developing the desired power at a reasonably low speed was designed. Its cylinders, of which there are six, have a 7½in. bore and 8in. stroke, and the operating speed is 1100 revolutions per minute. The cylinders, which have removable liners and dual heads, are of the valve-in-head type with two exhaust and two intake valves to each cylinder. They are furnished with water jackets, the water being circulated by means of a centrifugal pump. Fuel is supplied by means of a vacuum feed to the carburetter from tanks fixed under the car. Trunk-type pistons with four rings above the wrist pin and one scraper ring are used. The crank shaft, which is supported by seven main bearings, is hollow and arranged so that oil is forced through it to all the main bearings. There are two complete ignition systems, by means of two high-tension magnetos with impulse starters used with two complete sets of spark plugs. The magnetos are driven independently, and are of a single-spark type with manual advance and retard regulation. A centrifugal water pump is used for circulating the cooling water. The oil pump discharges oil to the lubricating oil header.

Two motors are used for starting the engine. A ring gear is mounted on the fly-wheel, and the motors, which are furnished with a Bendix drive, are mounted one on each side of the engine to mesh properly with the ring gear. The motors are connected in parallel across the terminals of a 32-volt battery when used to turn the engine over. One motor is, however, capable of bringing the engine up to sufficient speed for firing. The engine cooling water has its temperature regulated by a radiator of the ordinary fin and tube type mounted on the left side of the car. Air is forced through the radiator by a fan, which is driven by a suitable motor that obtains its current from the generator when the engine is in operation. The quantity of air can be regulated by shutters placed on the radiator.

The generator and engine are mounted as a unit on a common bed-plate, and a flexible disc coupling with four 16in. discs is used for connecting them together. The complete power unit is mounted longitudinally in the engine-room on the centre line of the car, the bed-plate being mounted on rubber blocks supported from the centre sills of the car body. The generator is of a type specially designed for service with a petrol engine in a rail car. An exciter, mounted directly on the shaft of the main machine, is used for exciting the main field winding and also for supplying power at a low voltage for the car lighting circuits and for charging the battery. The exciter field receives its excitation from the 32-volt battery. Each machine has six poles. The main machine operates at 600 volts with normal load at 1100 revolutions per minute, and the exciter at voltages up to 60. The principal feature of design is the constant output characteristic of the generator to prevent overloading the engine, which is said to be so satisfactory that the engine runs at constant speed over a wide range of current values, i.e., a wide variation in car tractive effort. The constant output characteristic was obtained by placing a differential series winding on the poles of the exciter and passing the main motor current through it, so that variations in field strength that are inversely proportional to the current load are obtained, the voltage dropping off in proportion to increases in current demand. The generator is provided with an extra wide commutator, large brush area and commutating poles to insure good commutation at all loads, and its spindle is mounted in ball bearings.

Limitations of space and weight demanded that the greatest possible ventilation should be obtained with a minimum of extra apparatus. The arrangements chosen greatly aided in this, as a one-directional fan could be used on the generator shaft, by which large quantities of cooling air are drawn through the machine. It is fixed at the engine end of the generator and draws the air in over the commutator which is next to the outer bearing. The generator supplies power to two 140 horse-power motors arranged on the forward truck of the car. They are standard 600-volt direct-current motors, with commutating poles, and they are constructed with solid frames, with openings to permit circulation of air by means of a fan on the motor shaft, and are axle hung, the drive being through strong solid helical gears, having a maximum ratio of 16 to 61, which are totally enclosed and run in grease. This large gear reduction was used to give the high tractive effort necessary with trailer operation.

The control for the car is exceedingly simple. Two unit switches are employed for connecting the motors to the generator, and there is also a reverser for changing the direction of current flow through the motor fields, and hence the direction of car operation. They are of the electro-pneumatic type generally used for equipments of this size, and their operation is governed by a master controller. The car speed varies with the generator voltage,

which is regulated by governing the engine speed, *i.e.*, the engine throttle setting. A sequence drum with a cam with the necessary push rods to the throttle is fitted on the engine. The position of the cam determines the throttle setting and hence the engine speed. The movement of the drum is regulated by the same master controller that operates the unit switches and reverser. The operator, therefore, has only one control to use for operating the car. The first movement of the master controller closes the unit switches and also a relay that energises the exciter field. Further movement of the master controller only causes further rotation of the sequence drum, *i.e.*, the opening of the engine throttle. All the control apparatus, including a number of knife switches for the motors, generator fields and battery circuits, are arranged on a rack and panel on the generator.

A battery charging regulator is placed between the variable voltage exciter and the 32-volt battery, and an additional regulator is placed between the battery and all the 32-volt load circuits. There is a two-directional ammeter to indicate battery charge and discharge. An oil gauge and an engine tachometer are also fixed on the engine. All the instruments are readable from the operator's position.

As the sequence drum determines only the engine speed, it is a very easy matter to operate two or more cars from one position, for it is a matter of placing the control wires in parallel and notching up the two drums together. There is a master controller on the rear end of the car to permit of double-end operation. Where continuous operation of a two-car train is desired a master controller can be placed on the rear end of the trailer car so that the necessity of turning the whole is eliminated.

Two air-storage tanks under the car provide compressed air for the air brakes, whistles, bells, sanders and the electro-pneumatic switches and reverser. They are kept charged by a motor-driven compressor having a capacity of 20 cubic feet per minute, which is cut in and out automatically. The lighting is furnished by a 160 ampère-hour 32-volt storage battery, which is kept charged by the exciter mounted on the engine generator set. It is this storage battery which also actuates two electric starting motors on the engine. Standard regulators keep the lighting and charging voltages constant.

The Reading car is capable of speeds up to 51 miles per hour, and is able to haul a standard railway coach in regular service. The gear ratio on this type of car determines the maximum speeds that can be attained. Balancing speeds on the level up to 55 miles per hour are possible with smaller reductions between the motors and wheels.

For the particulars contained in the foregoing and for the accompanying illustrations, we are indebted to Mr. T. H. Murphy, general engineer of the Westinghouse Electric and Manufacturing Company, of East Pittsburgh, Pa.

The Present Outlook for British Shipbuilding.*

By A. C. F. HENDERSON.

IT may be said that the subject of this paper is somewhat redundant, in view of the recent inquiry into the conditions in the shipbuilding trade, from which we all hope much good may result, but with this view I venture to disagree. In the first place, it seems to me that the shipbuilding trade cannot be considered alone, as its past, present and future is so bound up with the kindred industry of shipowning that it would be a good thing if the whole subject could be considered and discussed from all sides. Whilst on this subject, although I do not want to broach anything of a controversial nature, may I be allowed to say, purely as a very amateur shipbuilder, but as also representing the owners, that I feel sure it would be of mutual advantage in the future if both industries considered and discussed together the matters coming under the purview of this Institution, more in collaboration than has been the case in the past.

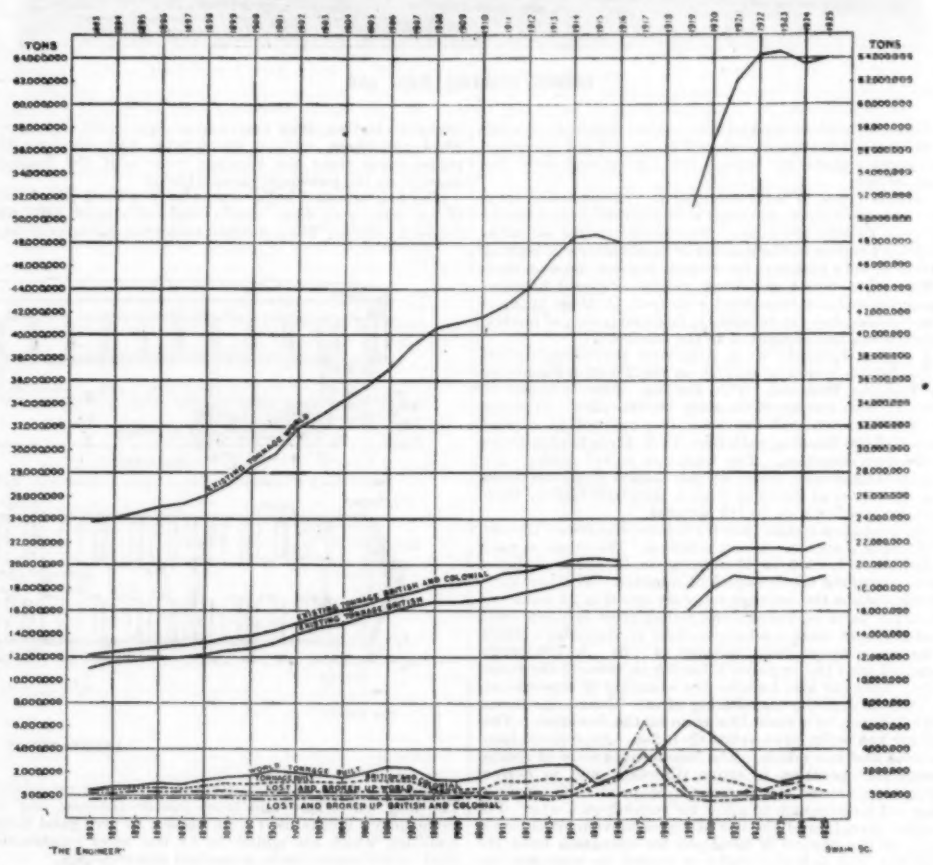
In trying to make any estimate of what is likely to happen in the future, of the likely course that events will take, it is necessary to study what has gone before, and before going any farther I should like to call your attention to some very interesting facts revealed by the accompanying diagram.

The first thing that strikes one on looking at it is the position that Britain and her Dominions occupy, and have occupied, in the world's tonnage position. In the year 1893 their total was 12,788,282 out of a total of 24,236,865, or 52·76 per cent. This position, with slight variations, continued until the year 1900, but from that date our premier position began to decline, although our percentage remained fairly constant until 1912, when the world's tonnage grew a great deal faster proportionately than British and Dominion tonnage. The growth all along has really been in the British figures, as Dominion tonnage only increased by 50,000 tons during nineteen years. At the end of the war we had actually 2,400,000 tons less than in 1914, although the world's tonnage had grown in the period by nearly 2,000,000 tons. Since 1919 we have made up the deficiency and now possess more tonnage than we have ever had, but owing to the large fleets built by the United States and other nations, our percentage of the world's total has fallen considerably. There is reason to hope, however, that a great many ships built during the war will, when scrapped, never be replaced, and that this country's proportion will thereby benefit. This is borne out by the fact that whilst the world's tonnage last year was less than in 1923, the British tonnage increased.

As regards the figures for tonnage lost by casualty and broken up, the one fact that stands out is the very slight variation that has taken place during the period in question, either in the world's or British figures. This is even true during the period of the war, if we exclude the figures of purely war losses. There are, however, two periods of exception to this regularity—namely, during 1909–11 and the last four years—both brought about by the economic necessity of the day. This, I think, is an encouraging sign, both from a shipbuilder's and shipowner's point of view, and you will notice that in the year 1923 the tonnage lost and destroyed exceeded that built by over 700,000 tons, and in the following year the tonnage built was only in excess by the small margin of 390,000 tons.

The curve for tonnage built is perhaps the most interesting of all, and illustrates very graphically that whilst the world's population, and in consequence its trade, goes on increasing decade after decade, the tonnage built does not generally follow the same curve, but varies according to limited periods of years within fairly narrow limits. This would seem to show that shipping, unlike other forms of the utilisation of capital, is more of an opportunist trade, not anticipating an increase, and that generally, except in very exceptional times, there is a large volume of tonnage in excess of the world's demand.

The period that I have taken in my paper covers several distinct phrases, but I am not alluding to the war period, except in its effect, as that was distinctly abnormal. The first six years, 1893–1898, were distinctly ordinary, but the next five were moderately good with the year 1901 reaching a peak. The following year saw a slight drop, but the next three were good years. We then entered a very dull three years, and it was not until the year 1911 that shipbuilding really became active again, and in that year and the three following the tonnage launched was never exceeded until the war and the after-war periods. The latter periods need, of course, no explanation, but what is interesting to note is that the high rate of building by the world was protracted long after the war, and it was not until the year 1922 that the amount became more or less a pre-war normal figure.



The British figures followed very closely the world's figures which I have quoted, except that an increase began in 1908, a year earlier than the world's figures, whilst the world's drop in the year 1904 was protracted over the previous year also in the case of Great Britain.

The percentage of building done by Great Britain as against the world's total has also been a gradually reducing figure, coming down from above 80 per cent. to nearly 50 per cent., except during the war, which was abnormal. This is only to be expected on account of the natural desire of other countries to build for themselves. I think, however, we can look forward to preserving the total percentage we now build, and perhaps even increasing it.

Now as regards what is really the subject of this paper—namely, the outlook for British shipbuilding—I must confess that I speak with a considerable amount of diffidence, realising as I do that the *rôle* of a prophet has never been a popular one. On the other hand, we start, with things as they are to-day, from the best possible basis for our purpose, as whatever figures we arrive at are more likely to be exceeded, rather than the reverse.

To secure some sort of basis on which to work, I have divided the figures since 1893 into the periods, taking the figures for British building only, and the following averages are the result :—

Period.	Average, tons.
1893–1897	989,219
1898–1902	1,435,825
1903–1904	1,197,890
1905–1907	1,686,467
1908–1909	960,364
1910–1914	1,660,246
1920–1925	1,299,154
1921–1925	1,147,860

In order to try to arrive at some sort of figure which would seem to be a near estimate of what we may expect in the near future, I have worked out the calculations on the basis of each of two periods. In the case of the period 1908–1909, I have added 10 per cent. as the addition to shipbuilding figures due to better trade, and in this connection I think an improvement in trade will be more quickly reflected in the figures in the near future than has been the case in the past. I have also added 111,481 tons as representing the difference between the average shipbuilding done for foreign countries in the last two years, and a more normal total of 250,000 tons. In the case of the years 1921–1925, I have first of all deducted 150,000 tons before making the other additions. This figure represents, in my opinion, a very fair estimate of the excess of normal building owing to the rapid replacement by liner companies due to war losses, and the consequent increase over what may be termed normal figures. In addition to this, the same calculations as in the previous period have been made.

The results of the two calculations are as follows :—

	Tons.
Period 1908–1909	1,167,881
Period 1921–1925	1,209,127

This is perhaps not a very satisfactory result from the British shipbuilders' point of view, but if we taken an average of the two periods, namely, 1,188,504 tons, it does represent a slight advance over last year, and not the reverse, as many of us might have expected.

I have said before that prophecy, or rather the attempt to prophesy, is not a satisfactory business, and I again repeat that. At the same time, let us remember the following facts :—

(1) That we are starting from the very worst basis from a trade point of view, and that therefore all indications are that the trend of the curve will be upwards.

(2) That British invention and initiative are never so keen as when they are up against a very serious position.

(3) That a large amount of tonnage at present in existence is now useless without large expense, and in a few years' time will in any case be useless.

(4) That there are distinct signs of a trade revival, especially in passenger business, and although this may be slow in the shipowning trade, it will have its effect on the shipbuilding business.

(5) That we still have as good, if not the best, operatives as any in the world in shipbuilding, and given some revival in the industry, a new generation of workers will grow up in the industry, for whom the incentive does not at present exist.

Taking all the above facts into consideration, I think we can confidently look forward to something in the neighbourhood of 1,200,000 tons for British shipbuilding construction in the current year, and perhaps its eventual improvement next year.

* Paper read before the Institution of Naval Architects on Wednesday, March 24th. Abridged.

Doubling the Inner Circle.

FOR months past the Metropolitan Railway has been actively engaged in constructing a junction, at a point east of Euston-square, to link up and utilise a length of disused tunnel extending to Kings Cross by means of which it will be possible to switch over Metropolitan trains from the Inner Circle line to the widened lines and thus secure an alternative route to Moorgate. This work, which has been found necessary to keep pace with the Metropolitan's increasing traffic, and which will have the effect of doubling the most important section of the Inner Circle, was com-

pleted on Monday, March 15th, and a duplicate service of electric trains is now being provided for the first time over line hitherto solely operated by steam trains.

To gain access to the tunnel in question, which was constructed about sixty years ago and is approximately 1200ft. in length, a difficult engineering feat has had to be performed, for the whole of the work had to be effected without deranging the existing dense train service. The work was carried out on the cut-and-cover system, and involved the cutting away of a considerable length of the Circle line tunnel roof and wall; the introduction of a series of heavy steel girder to support the Euston-road, which is immediately over the railway; the diversion of a large sewer and a maze of gas and water mains and electric cables and conduits; the construction of 700ft. of single tunnel, and also the provision of a junction at the eastern end of the old tunnel in order that the widened line might be reached.

Concurrently with these operations the Metropolitan converted from steam to electric traction the widened lines which extend form Kings Cross to Moorgate, and over which now operate the steam trains of the Great Northern section of the London and North-Eastern Railway and the Midland section trains of the London, Midland and Scottish Railway.

These lines have been equipped with the latest type of signalling and every other attribute characteristic of modern Metropolitan practice has also been provided. The signalling included the erection of 103 main line signals and repeaters, and the provision of 70 new alternating track circuits. The control of the junction of the new line with the existing Metropolitan track near Euston-square Station will be effected by means of a specially devised electrical apparatus contained in a signal box situated at Kings Cross nearly 700 yards away, and from that box will also be worked the junction points with the London and North-Eastern and London, Midland and Scottish Railways.

At Moorgate a considerable rearrangement of the terminal part of the station has been made. Next to the "Down" Circle platform a double line terminal bay has been made for electric trains; while the steam trains of the London and North-Eastern and London, Midland and Scottish Railways will be accommodated in two single line bays. A new double story fire-proof signal cabin, containing the most modern of electrical controlling devices, has been erected at Moorgate. This new signal-box replaced the previously existing signal-boxes.

With the opening of the new junction a greater freedom of movement will be brought about, and a number of "through" trains from the Metropolitan will be diverted to Moorgate, *viâ* the widened lines, thereby enabling the "through" trains to be expedited in both directions.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

CONCRETE ROADS.

SIR,—The question of reinforced concrete roads for factory approaches has recently been of interest to me, and I have in consequence been endeavouring to collect some data on this subject.

Paragraphs and articles I have read in the Press concerning the recently constructed Reigate–Dorking road prompted me to observe its condition when an opportunity of doing so recently occurred, and I may say at the outset that one could not be other than favourably impressed with the general result that has been achieved.

May I, however, through the medium of your valuable columns, raise the question of the ultimate effect of the numerous cracks which are apparent in the road, but which as they occur are apparently being filled in with a suitable bituminous grouting? Also at several points I observed that parts of the concrete have apparently broken away from the main raft, and it occurs to me that both of these conditions must ultimately produce disintegration.

The existence of the cracks alike in cutting and embankment sections of the road would appear to obliterate their being entirely attributable to settlement of the foundation. Insufficient drainage of the foundation might conceivably be contributory to the production of cracks, but such a condition, even if it existed, would, of course, be common to any type of road construction.

The method of construction appears to be that the concrete is laid in alternate sections, about 12ft. to 14ft. in length, across the full width of the road, and when these have set the intermediate sections are concreted hard up to the existing sections.

My observation, however, of the work in course of construction did not reveal how an efficient expansion joint can be effected in this way, especially as it appeared that the reinforced metal extends from one section to another with a definite overlap. I am aware that this is common practice over short sections, but it would be interesting to know whether, if I assume correctly, such a system if it exists over a considerable distance might not produce cracking.

An article in a recent issue of the *Surveyor*—February 5th—on the subject of this particular road contains detailed information in regard to the methods of construction. May I refer to what is there stated as to the two respective 6in. and 2in. concrete layers in relation to that section of the same article on the subject of reinforcement, whereby it would appear that the bottom of the upper reinforcement exactly coincides with the junction of the two lamina of concrete? In the same article the author also refers to the amount of water used in mixing concrete as 22 per cent. of water (by weight) of the cement. It would be interesting to know whether this refers to the top or lower layers, which appear to contain obviously different proportions of water.

Reverting to the question of expansion, one suggestion would appear to be that the best expansion joint would be an air gap of, say, ¼in., the abutting edges of the concrete section being reinforced with light angle iron flush with the surface. This would permit of the free expansion of each section, with no damage to vehicle or roads and the edges of the joints would be entirely protected.

It is possible that concrete roads might be built successfuly without expansion joints, depending on the fact that they are free to expand laterally, and that their longitudinal expansion is arrested by opposing compressive forces causing a strain—deformation—equal to the extent of elongation under co-efficient of expansion.

For this reason it is fairly obvious that the principal distribution of steel must consist of rods parallel and transverse with the centre line of the road. On the Reigate–Dorking road, however, the steel grille reinforcement appears to be laid oblique to the centre line of the road. Must it not set up stresses of a somewhat unknown character?

W. A. TREVOR TAYLOR, M.I. Mech. E.

March 1st.

JACOB PERKINS' ENGINEERING WORKS "TO LET."

SIR,—Within the last few days notices have appeared "To Let" on the most famous steam engineering works in London, and on which is still visible the sign—

A. M. PERKINS & SON,
LIMITED,
ENGINEERS

over its goods entrance in No. 7, Seaford-street (formerly Francis-street), Regent's-square, Gray's Inn-road, W.C. 1.

Perkins was the first manufacturer in the world to make the uniflow engine, simple, compound and—at least proposed—also triple-expansion. He invented, patented, made and licensed out the manufacture of the uniflow engines from 1825, as described at length in the British, German, French, Swiss and American weekly and annual engineering and chemical trades journals of that period, and it was in these works, now to let, at Seaford-street, that he demonstrated by brake tests on a uniflow engine, operated simple first and compound afterwards, the entire fallacy of that theory, attributed to Dr. Robison, and still printed in all steam engineering text-books: "The total work done in two-staged expansion cylinders is the same as if the steam was used in the low-pressure cylinder only, the total expansion being the same in both cases." Yet the pressure indicator proves this dogmatic statement to be false as regards actual working engines, in which the high compressions and dead centres block thrusts are such that it is impossible of realisation, as every engineer knows from the familiar curl-up of the steam consumption curve at the low torque end shown in all curves of steam consumptions in uniflow engines, equally as in Bonnefond trip gear locomotives giving ideal "stationary engine" cards at 5 per cent. cut-off. Here, in Seaford-street, before engineering celebrities, in 1828, Jacob Perkins proved by brake tests that the exhaust steam from one uniflow cylinder when used in another eight times larger gave about 70 per cent. more power on the brake; but the theorists of the "old school" refused the evidence of their own eyes, and still maintained that it would require continuous increments of heat bled direct from the boiler to obtain that power increase in the large cylinder.

Engineers are reminded of these experiments and that the "old school" persists, by an article in the current—February—issue of *La Revue Générale des Chemins de Fer*, by M. Vallantin, dealing with staged expansions as the universally known means to increase the mean effective pressures by 50 per cent., while decreasing the initial stresses by 30 per cent., and thus to prevent wheel slipping, with a low adhesion factor, when restarting with rapid accelerations 700-ton express trains after signal checks on long banks. In answer to a request for designs for a new 4–8–2 express engine, based on these specific P.L.M. experiences, the new designing department of the amalgamated French railways, "O.C.E.M.," made a daring but abortive attempt to revive those superseded assumptions and subjections by throwing the whole of the boiler pressure at dead centres into two single cylinders on two crank-pins. This amusing episode reveals how deeply implanted are the old theories against which Perkins contended in 1828.

Concerning the now vacant "Perkins" works, Messrs. Rooke Brothers, "wireless" manufacturers, occupiers of one part until February, expressed some months ago their personal feeling that they were none too keen on Press notices referring to the work of Jacob Perkins in these premises, because in their view such publicity might prompt some rich engineering society to make a bid for a part of them to found there a library, club, or Perkinsians—or something more than a L.C.C. commemorative plaque over No. 7—likely to disturb a tenancy which they had no desire to discontinue. The apprehensions of Messrs. Rooke may have been prophetic. The principles of steam generation, as originated by Perkins, are being re-patented year after year by Swiss and German firms, in testifying to his remarkable genius fully a century in advance of his time.

The Perkins works are comprised between Regent's-square (No. 43), Seaford-street and Harrison-street, the property formerly including workmen's dwellings. Relics of the Perkins firm still visible are Perkins' main steam pipes, a full-gauge shop railway, the "A.M.P." heating boiler and a deep artesian well with pumps. The site is marked by St. Peter's Church in Sidmouth-street. It is within the throw of a stone from the graves of Macaulay and the daugher of Cromwell. A small baker of the name of Nevill, in Sidmouth-street, had the first opportunity of using the famous superheated steam ovens made by the Perkins firm. To-day the same firm still uses Baker-Perkins machinery.

March 23rd. C. R. K.

THE HIGH EFFICIENCY OIL ENGINE.

SIR,—In common with, I think, several others, I was somewhat disappointed last Friday by Mr. Chorlton's failure or disinclination to deal with the commercial aspects of heavy oil engine improvements in his paper before the Institution of Mechanical Engineers. He concentrated his attention on the possibility of effecting thermodynamic and mechanical improvements with the object of obtaining higher efficiencies. While he showed in an able and convincing manner that such possibility, technically regarded, was well within reach, he completely omitted to demonstrate that its attainment would yield a farthing's worth of advantage from the commercial point of view. Many engineers concerned both with the design and the operation of heavy oil engines would, I feel sure, welcome an authoritative lead on the subject.

Fuel oil at £4 per ton costs 0·43d. per pound. If the normal consumption of an engine is 0·4 lb. per brake horse-power hour, and if by improving the design the consumption is reduced to 0·35 lb., the economy effected in the running expenses will be 0·0215d. per brake horse-power hour. At 3000 hours per year the annual economy represented by the reduced consumption will be 5/4½ per brake horse-power. At 5 per cent. per annum that sum represents the interest on £5 7s. 6d. If the improvements can be effected without raising the first cost of the engine by as much as £5 7s. 6d. per brake horse-power, it will pay to adopt them. If, however, they raise the price by more than this amount they will result in a net annual loss.

I do not know whether it is safe to take the average cost of a heavy oil engine at £10 per horse-power, but if it can be so taken the above simple calculation shows that the designer who improves the engine at the expense of increasing its first cost by 50 per cent. or more is not likely to reap any reward for his labours. No doubt £5 7s. 6d. per brake horse-power is a considerable sum to have in hand, but the designer must remember that to justify his improvements they must be effected at a cost well within that figure, probably at about £2 10s. to £3 per brake horse-power to be really acceptable. Can it be done?

It may also be noted that to effect a second improvement of 0·05 lb. in the consumption, the designer is limited to the same maximum permissible increase in the capital cost of the engine as in the case of the first improvement, although the second step must naturally be much more difficult to accomplish than the first.

It must not be overlooked, too, that fluctuations in the price of fuel oil have an influence on the problem. For instance, if after the improvements have been made and adopted the price of fuel oil falls from £4 to £3 per ton an economy of 0·05 lb. per brake horse-power hour in the fuel consumption represents an annual saving of only 4s. per brake horse-power instead of 5/4½. If then the improvements are effected at the expense of increasing the first cost of the engine by £4 or more per brake horse-power, the purchaser when the price of oil fell would either experience no gain or suffer a dead loss on the bargain. To allow for possible falls in the price of fuel oil it would appear that the improvements suggested by Mr. Chorlton would, to be acceptable, have to be effected at a cost not exceeding about £2 per brake horse-power. Again I would ask, can it be done?

According to the figures collected by the Diesel Engine Users' Association, the fuel costs for a Diesel type engine on land represent almost exactly 50 per cent. of the total average running expenses. An economy of *n* per cent. in the fuel consumption therefore represents an economy of *n*/2 per cent. in the total running expenses. The reduction of the fuel consumption from 0·4 to 0·35 lb. per brake horse-power hour implies an economy of 12½ per cent. in the fuel bill, and therefore of 6¼ per cent. in the total running expenses. Is such an economy sufficiently attractive to be worth great efforts to realise it?

The general impressions I get from this brief study of the commercial aspects of Mr. Chorlton's subject are first, that the maximum economies to be secured by the improvements suggested will yield a sum sufficiently large to prove attractive only if the engine considered is of fairly high power; and secondly, that judged by the final standard of the commercial balance sheet, the reduction of first cost of the engine without alteration of its consumption offers at least as promising a line of advance as its development in the direction of lower consumption and, presumably, higher first cost. S. F. C.

London, March 23rd.

THE BRITISH INDUSTRIES FAIR.

SIR,—With reference to the British Industries Fair, which it is stated will be held in 1927, might I suggest for the consideration of the President of the Board of Trade that he should take more adequate steps to prevent the exhibition of foreign goods, as purporting to have been made in this country?

I attended this year both at Birmingham and the White City with the buyers of my own company. They named to me, in several cases, the works in Sweden where goods exhibited as British had been manufactured.

I would suggest as a test that exhibitors should be compelled to give a bond equal to, say, ten times the rental of their stand, that the goods exhibited were wholly produced or manufactured within the Empire.

Next, might I suggest that encouragement should be given to firms such as my own, who do not sell direct to the public, but distribute through recognised channels, to accepted retailers, goods produced in Great Britain, not necessarily manufactured by the distributors.

The modern tendency seems to ignore one of the largest trades in the country, that is, the recognised distributing agencies who sell to the small dealers goods produced by many manufacturers.

These firms could probably show greater ranges of British-produced goods than any group of manufacturers, and they occupy such an important position in the trade that facilities should be given to them to exhibit, and endeavours made to attract them to this Fair.

In my opinion, one of the principal reasons why such distributing firms do not exhibit is the admission to the Fair of the public in the evenings. Customers of these firms, the small shopkeepers, are much afraid lest these large firms should develop general mail-order and direct business with the public, and the wishes of their customers must be recognised if the distributing firms are to continue to fulfil their function.

A. L. JOHNSON
(Johnson, Clapham and Morris).

Manchester, March 22nd.

IN the Symons Memorial Lecture, which was recently delivered before the Royal Meteorological Society by Professor Sydney Chapman, F.R.S., under the title of "Some Recent Advances in Atmospheric Physics," it was explained that the existence of a strongly ionised layer in the upper atmosphere, required by theories of the daily variations of the earth's magnetism, and also required to explain the long-distance transmission of wireless waves, had recently been strikingly demonstrated by observations of high-angle reflection of short-wave wireless signals at night. The wireless and magnetic data for the ionised layer were found to be in fair qualitative and also quantative accord where they overlapped. It appeared possible, the lecturer said, to explain the production of the ionisation by ultra-violet radiation absorbed in the atmosphere by day, certain quantitative difficulties proposed by Swann being found invalid. Additional ionisation occurred by night as well as by day, in higher latitudes, in association with auroræ. The nature of the ionising agent in that case was somewhat obscure, but a stream of charged corpuscles of opposite signs, but with a slight residual charge, seemed the most likely hypothesis. The auroral spectrum suggested that nitrogen was the principal ionised gas in the auroral regions.

Hydraulic Cargo Cranes on the Motor Liner Asturias.

In the course of our article on the R.M.S.P. motor liner Asturias, which was published on February 26th, brief reference was made to the hydraulically-operated cargo cranes which are installed on that ship. By the courtesy of the crane builders, Fullerton, Hodgart and Barclay, Ltd., of

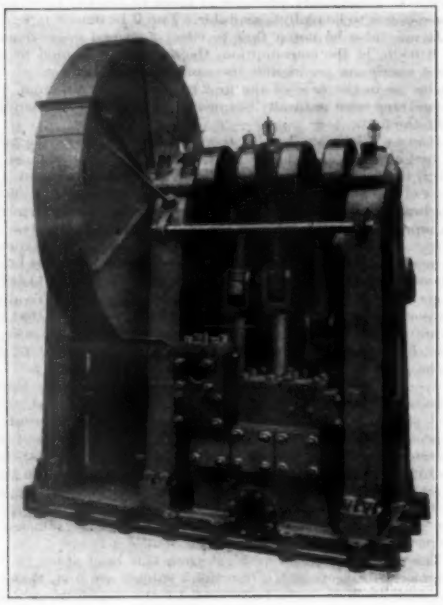


FIG. 1—HYDRAULIC PUMPS

Paisley, and the owners of the vessel, we are enabled in the present article to give some further details of this machinery. Essentially the equipment comprises two sets of motor-driven hydraulic pumps, with a Ward-Leonard electrically-controlled motor-generator, an air-loaded hydraulic accumulator, and twelve hydraulic cranes which serve the six cargo hatches. A small motor-operated pump is also fitted, the purpose of which is to circulate warm water through the system, so that in cold weather any possible damage by frost is obviated.

Hydraulic Pumps and Control Gear.—The two sets of hydraulic pumps—one of which we illustrate in Fig. 1—are placed on the starboard side of the auxiliary engine-room. Each pump is motor-driven by a 110 brake horse-power Laurence Scott motor mounted on the back of the frames. Single reduction double helical gearing, totally enclosed, is provided. The pumps are of the vertical three-throw single-acting ram type, and have 4½in. diameter rams, with a stroke of 12in. A maximum speed of 60 revolutions per minute is allowed for, but a wide range of speed regulation is obtained by using a special motor-generator with Ward-Leonard control. The motors take their supply of current from the motor generator, which is fed from the ship's supply mains. A contactor type of starter is fitted to the motor-generator, which runs up the equipment automatically, and is normally left in circuit when the cranes are likely to be in use. A speed control from about 600 revolutions per minute to 50 revolutions per minute is obtained by a series of six tappet switches fixed on the accumulator, which close as the accumulator ram falls and cut out resistance in the generator field, thus increasing the voltage and therefore the speed of the pump motors. When the accumulator is in its top position there is sufficient field left on the generator to give a pump speed of about five revolutions per minute. This makes up for any leakage in the system, and during this time the pumps work against a relief valve discharging back into the suction pipe. As the motor is turning slowly, the danger of flats forming on the commutator owing to current passing through a standing motor is thereby avoided.

In order to enable the attendants to stop the motor-generator and to limit the maximum speed obtainable by automatic regulation, a small master barrel type controller is fitted. It is provided with an "off" position and also a series of running notches, which positions correspond to the maximum speed obtainable with the six tappet positions previously referred to. By such means a hand control is provided, which may be used if any for reason the automatic tappet switches are thrown out of action. All the electrical gear referred to above was supplied by Laurence, Scott and Co., Ltd., of Norwich.

The Accumulator.—The hydraulic accumulator—which is shown in Fig. 2—is of the vertical air-loaded type. It has a ram 12in. in diameter with a stroke of 6ft. Air is taken under pressure from the engine-room air storage receivers, and the size of the air cylinder is so dimensioned that a mean hydraulic pressure of 1000 lb. per square inch is obtained.

The accumulator is controlled by a tappet rod which works in conjunction with the switches controlling the speed of the pump motors. A control rod is attached to the underside of the air piston, and it passes through the bottom of the air cylinder. At its lower end it is furnished with a double tappet piece and a pointer working over an index. On the front columns of the accumulator are mounted two boxes which contain the regulating switches for the pump motors.

When the accumulator ram is at the bottom of its stroke the switches are so arranged that the motors receive the maximum voltage and run at full speed. They continue to do so until the tappet rod moving upward with the ram and piston comes into contact with the switch fingers and puts in resistance to the generator circuit step by step.

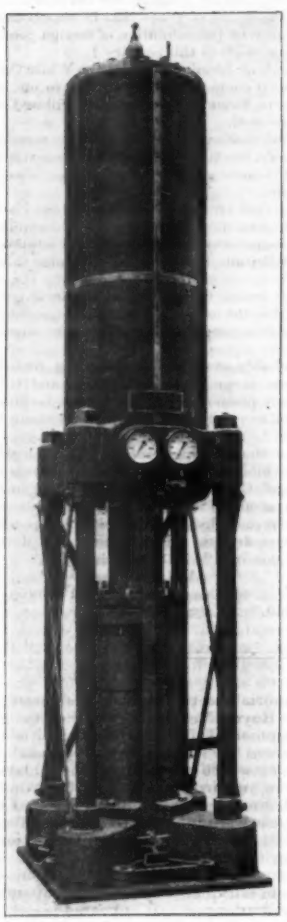


FIG. 2—ACCUMULATOR

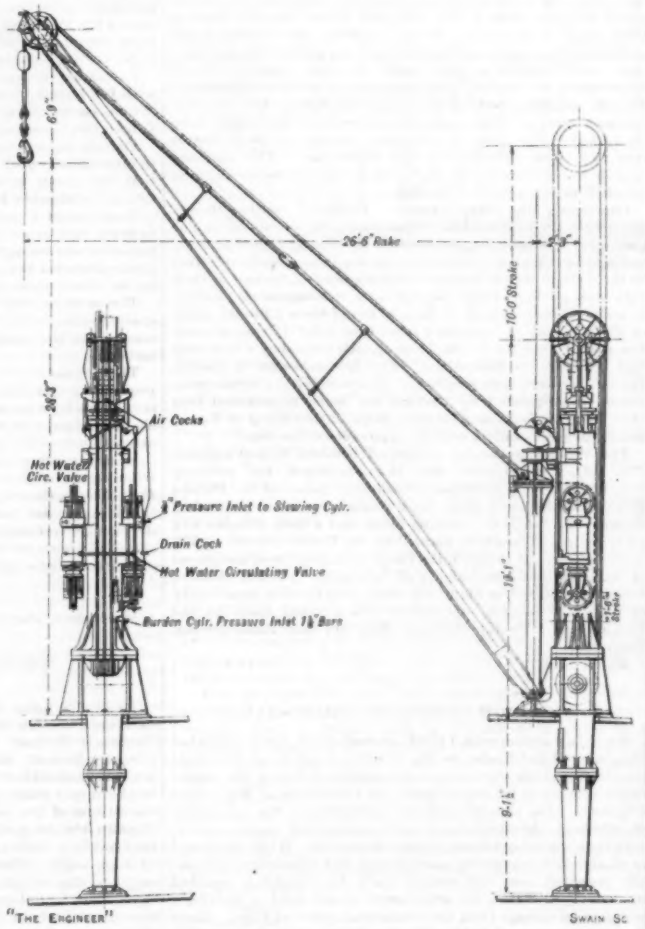


FIG. 3—GENERAL ARRANGEMENT OF CRANE

At the top of the ram stroke the speed of the motors and pumps is reduced to the minimum. The system is then fully charged, and the pumps are by-passing to the suction.

Assuming the cranes to be now in use, the accumulator starts moving down to cope with the demand for pressure supply, and at the same time the tappets operate the switches in the reverse direction, and so bring up the speed of the pumps. Before the ram has moved down more than half stroke the pumps are giving their full delivery.

If it is desired to use one pump only a master switch is provided which completely cuts out the other pump, even although the tappet rod is still operating both sets of switches.

Cranes and Pipe Connections.—The hydraulic cranes are of the slewing type, and two cranes are provided at each of the six hatches on the ship. Ten of the cranes are designed for a normal lifting capacity of 30 cwt. at a speed of 340ft. per minute maximum, whilst lowering is carried out at a speed of 400ft. per minute. Two of the larger cranes—one of which we illustrate in Fig. 3—are of the compound ram type, the inner ram being arranged to lift a load of two and a half tons, whilst the two rams operating together can lift five tons.

The height of lift for the 30 cwt. cranes varies from 60ft. to 89ft., and the outreach from 24ft. 9in. to 29ft. 6in. Two of the smaller cranes are arranged to luff a radius of 17ft. 6in., a special luffing ram being bolted to the swinging post of the crane, and the outreach of the jib so varied from 17ft. 6in. to 24ft. 9in. The compound cranes—illustrated in drawing Fig. 3—have a lift of 80ft. and an outreach of 26ft. 6in. All cranes are of the "eight-power" pattern—that is, for every foot moved by the crane ram the load moves 8ft., and all are designed to slew the load through an angle of about 160 deg.

The general construction of the two larger cranes may be noted from the accompanying drawing. A strongly ribbed stool is bolted down to the deck plates, and it carries the hydraulic cylinder in which the crane ram works. A swinging post to which the steel latticed jib is attached is stepped into the stool, and has its top end supported by a bracket bolted to the hydraulic cylinder. Both the post and the jib are rotated by two hydraulic cylinders, which are attached to the main cylinder, and turn the post by means of a heavy chain fixed to the top of it.

The burden rope has its standing end made fast to a lug on the main cylinder, and passes over a series of pulleys on the ram head and on the bottom cover of the main cylinder. After passing under a swivel pulley, which is pivoted in the top crane post bracket, the rope is then taken over the jib head pulley to the crane hook.

In the compound crane—illustrated in Fig. 3—it will be seen that there are two coaxial burden rams. For the 2½-ton lift only the small ram is in use, the outer ram being securely locked to the cylinder by gear operated from the deck. When 5 tons is lifted the outer ram is freed and the admission of hydraulic pressure causes both rams to move as one.

Each crane is controlled by small hand-operated slide valves, which are conveniently placed at the side of the hatch, so that the operator is in full view of the load as it comes up the hatch.

The pressure mains and the return water mains are made of mild steel tubing joined with forged steel flanges. Special provision is made for dealing with the effects of expansion and contraction. The return water from the system drains back into two tanks, which are placed in the engine-room, and are so arranged at a positive head of about 20ft. on the hydraulic pump suction is given. In order that any risk of damage by frost may be avoided, one of the return water tanks is provided with a steam heating arrangement. A small motor driven pump is fixed in the engine-room for the purpose of circulating this hot water into the pressure system, which is accomplished by a special setting of the crane operating valves. When the valves are so set the heated water passes through all the crane cylinders and return pipes back to the tank in the usual manner.

The High Efficiency Oil Engine.*

By ALAN E. L. CHORLTON, C.B.E., Member of Council.

A good deal of work has been steadily carried on since the war in this and other countries with the object of still further increasing the already high efficiency of the internal combustion engine.

The thermal efficiency of the steam engine, its great competitor, has also been materially raised by intensive methods, such as higher boiler pressures, higher degrees of superheat, interstage abstraction and feed heating, air regenerative heating, &c., and the good results obtained have no doubt all tended to spur on the internal combustion engineer to do better.

The advance in efficiency of the steam engine has perhaps been more rapid than that of the internal combustion motor, if we consider the high economy of the Diesel engine in its early days. These steam results, due to continuous detailed progressive development, are sufficiently encouraging to assail seriously the leading economic position held by the large slow-speed heavy-weight Diesel engine as used for marine propulsion, unless corresponding progress is made.

Another interesting feature is that in such development of the latest steam systems limits of pressure equalling those up to now, occurring within the internal combustion engine cylinder proper, are used with success, without any undue concern, in extended circuits exterior to the engine proper.

TABLE I.

Load	Full	0·53	0·375	0·25	None
Revs. per min.	154·5	157·0	158·0	158·0	159·0
M.E.P. L	113·4	64·7	51·9	38·2	46·2
M.E.P. R	114·5	74·1	69·7	46·2	39·7
I.H.P. total or mean	204·4	126·8	109·0	74·9	39·64
Net I.H.P. from the oil	201·1	123·6	97·0	71·93	36·66
Eff. H.P.	164·8	87·2	60·4	35·4	—
Mechanical eff.	80·7	68·8	60·4	49·2	—
Oil per net I.H.P. hour, lb.	0·333	0·329	0·309	0·356	0·415
Oil per eff. H.P. hour, lb.	0·408	0·465	0·505	0·724	—
Thermal efficiency on net I.H.P., per cent.	39·25	40·0	41·5	37·2	—
Thermal efficiency on eff. H.P., per cent.	32·3	28·3	26·1	18·3	—

* The Institution of Mechanical Engineers.

Experimental investigations carried out in this country on the internal combustion engine and published in scientific form have generally related to the constant volume or explosion cycle.

It would almost appear that the Diesel engine as it came into practice working on the constant pressure cycle became accepted as the final stage, without practical prospect of improvement from the efficiency point of view, of all heat engines using liquid fuel, and the earlier views envisaged were somewhat lost sight of. This may explain why its later results differ not very greatly from those obtained in the earlier days.

This is indicated by taking the results obtained by Mr. A. Clark, given in a paper read before the Institution,[1] and later figures such as were given in the report on the trials of the Sycamore and shown in Tables I. and II.

TABLE II.

Authority.	Mech. eff.	Fuel consumed, lb. per b.h.p. hr.	
Ade Clark	80·7%	0·408	"The Diesel Engine," I.M.E., 1903
Marine Oil Engines Trials Committee	79·8%	0·425	T.S.M.V. Sycamore, I.M.E., 1924

It should be noted that in a test on the Pacific Trader with airless injection the fuel consumption is given as 0·40 lb. per brake horse-power hour, and the mechanical efficiency as 87 per cent.

Sir Dugald Clerk and Captain Sankey in the "James Forrest" lectures of 1904 and 1925 dealt with the object of further economies in the engine. The former has also many times reviewed the possibilities of well-known cycles and their efficiencies, showing, as is well known, that better results can be obtained by the constant volume cycle than with that of the constant pressure cycle.

The practical difficulties in the development of the constant volume cycle appeared to limit construction to no higher than a certain compression ratio, and hence it

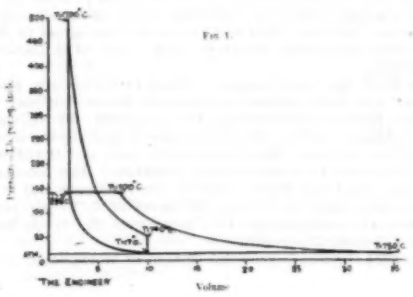


FIG. 1.

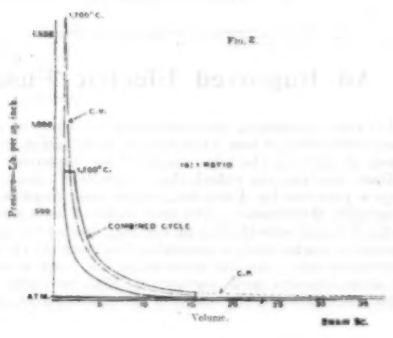


FIG. 2.

followed that the only gains that could be hoped for were those that could be made through other channels, by improvement in the details of the cycle, so to speak.

Consequently in later years, quite a big volume of work has been done in connection with supercharging, decrease of maximum flame temperatures, use of cooled exhaust, stratified charging, and so on, all of which, whilst valuable, are somewhat in the nature of refinements, as compared with what may be possible along the main line of development.

The main line of development in the improvement of the efficiency of the internal combustion engine has always been by the increase of the compression or expansion ratio, and it is suggested that it is in this direction that further progress is still possible.

Apart from the apparent belief that practical difficulties beset the use of an increase in the compression ratio with the constant volume cycle, it is suggested that an advance along these lines may also have been discouraged because of the suppression of heat; whether by variable specific heat, dissociation, or after-burning, so that such higher ratios would result in little, if any, practical gain.

Further, that the higher ratios were impracticable with the explosion cycle for reasons of pre-ignition, &c.; in the main, however, the construction of an engine to work under such conditions of high pressure or heat flow was not a practical proposition.

That there was some practical limit seems to have been felt by Clerk, for he says in a paper[2] read before the North-East Coast Institution of Engineers and Shipbuilders in 1919:—

"From the results of prolonged experience of internal combustion engines during many years, it may be taken that for explosion gas engines of the four and two-stroke types the extreme practicable compression ratio is one-tenth, and the maximum probable brake thermal efficiency 39 per cent."

Though gas engines are here mentioned, it is inferred that any other engines working on the explosion or constant volume cycle were included.

For a similar conclusion reference may be made to Dr. Walker's paper of 1925.[3]

Later work, however, has shown that there is a distinct practical possibility of progress in the direction of higher ratios, and it is the object of this paper to direct attention to it, and to give some results that have been obtained.

Without wishing to repeat what is well known and has so frequently been published, it helps the consideration of the subject to give some generally accepted basic data.

A usual comparison between the two cycles of common practical acceptance is shown by Fig. 1 taken from Sir Dugald Clerk's Cantor Lectures, read before the Royal Society of Arts in 1905. This figure shows both C.P. and C.V. diagrams having the same efficiency, but quite clearly shows that the efficiency of the constant pressure cycle depends on expansion to the atmosphere.

An extension of the previous diagram is given in Fig. 2 and illustrates a compression ratio of 16 to 1, based on the constant pressure figure, viz., with a maximum temperature of 1700 deg. Cent., as taken by Sir Dugald Clerk for the diagrams shown in Fig. 1; the air standard efficiency with this compression ratio is 67·7 per cent., against 61 per cent. for a compression ratio of 10 to 1.

The value of air standard efficiency for different compression ratios is given in Table III.

TABLE III.

$\frac{1}{r}$	E.	$\frac{1}{r}$	E.
	0·246	1/7	0·55
	0·36	1/10	0·61
	0·43	1/20	0·70
	0·48	1/100	0·85

It must then have been quite a material fear of the suppressed heat losses, mechanical difficulties of construction, &c., to have held investigators back, for the comparative efficiencies are, of course, well known.

A suggested variant of these cycles, the dual combustion cycle, was discussed in a paper[4] by Dr. W. J. Walker, before the Institution of Mechanical Engineers, in 1920, but as it is very doubtful whether either basic cycle is in practice ever correct in itself, and does not merge one into the other when adding heat, one might not unfairly consider this paper as being an analysis of practical heat addition, and as such is very valuable.

The investigations of Tizard and Pye[5] have demonstrated that the actual efficiency of the increased ranges of compression or expansion is greater, relative to the air standard, than had been anticipated, and that the indicated thermal efficiency may be expected to approach more nearly to that of the air standard efficiency as the compression ratio is increased.

Curves based on the results of Tizard and Pye are given in Fig. 3, in which Curve A shows the efficiency for a weak mixture, whilst Curve B is the usual air standard efficiency curve and C shows the ratio of A to B carried forward to a compression ratio of 20 to 1.

Stanwood W. Sparrow in a report[6] on the effect of changes in compression ratio, shows that an increase in brake horse-power and a decrease in the pound of fuel used per brake horse-power hour results from an increase in compression ratio. This is shown to be true at least up to the highest ratio investigated, namely, 14 to 1, provided there is no serious pre-ignition or detonation.

Fig. 4 shows the close agreement between the observed increase in efficiency and that which would be expected from a comparison of air cycle efficiencies calculated with an exponent of 1·4.

The dotted curve and the points in the figure are derived from actual tests.

Some experimental results obtained by A. F. Burstall[7] on a high-speed gas engine show that the relations between thermal efficiency and compression ratio appear to follow the same law as that given by Tizard and Pye.

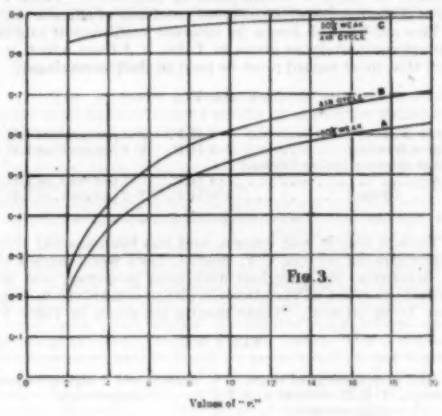


FIG. 3.

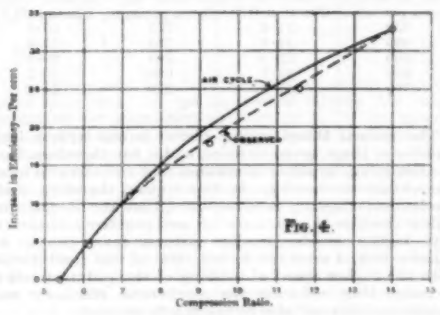


FIG. 4.

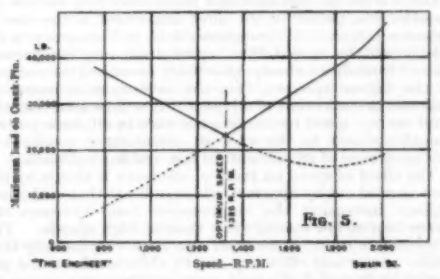


FIG. 5.

In reviewing the subject of the higher compression ratios, different ratios of compression were examined, with a view to comparing the prospects of improvement, taking for each case a certain maximum pressure.

In this investigation the maximum pressures and efficiencies were calculated from the formula given by Dr. W. J. Walker. Taking the case of a 13·25 : 1 compression ratio, the thermal efficiency is 64·6 per cent. for a maximum pressure of 1000 lb. per square inch, and a maximum temperature of 1500 deg. Cent. With a lower calorific value of the fuel equal to 18,300 B.Th.U. per pound the consumption per indicated horse-power under these conditions and allowing for no heat losses would be 0·216 lb. per indicated horse-power per hour.

With an efficiency ratio of 85 per cent. the consumption per indicated horse-power becomes 0·254; Captain Sankey's figure of 0·296 was calculated for a compression ratio of 13·1 with much lower maximum pressures and an efficiency ratio of 90 per cent.

TABLE IV.

Compression ratio.	Efficiency with a maximum pressure of 1000 lb. per sq. in.	Efficiency ratio.		Fuel per B.H.P. hour, lb.							
				Mechanical efficiency.							
		85 per cent.	90 per cent.	75 per cent.		80 per cent.		85 per cent.		90 per cent.	
		Fuel per I.H.P. hour, lb.		Efficiency ratio.							
				85 per cent.	90 per cent.	85 per cent.	90 per cent.	85 per cent.	90 per cent.	85 per cent.	90 per cent.
	Per cent.										
13·25 : 1	64·6	0·254	0·240	0·339	0·320	0·317	0·300	0·300	0·283	0·282	0·267
15 : 1	65·2	0·252	0·238	0·336	0·318	0·315	0·298	0·297	0·280	0·280	0·264
16 : 1	65·8	0·250	0·236	0·334	0·316	0·313	0·296	0·295	0·278	0·278	0·262
17 : 1	66·0	0·249	0·235	0·332	0·314	0·312	0·294	0·293	0·277	0·277	0·260

In comparison with the consumption figures actually attained in practice at the present time, these figures indicate that there is much to be done before the unavoidable heat losses are brought down to 10–15 per cent. This indicates particularly that atomisation should be given much attention.

The analysis of mechanical efficiency, with its prospect of improvement from the examination of available data, is an involved one, owing to the want of agreement in information from various sources. Some of these figures, it will be noted, are remarkably high, and it is difficult to follow how such efficiencies can be obtained from an inspection of the constituent parts of the engine. For a standard Diesel engine, Captain Sankey took the figure of 75 per cent., and it is thought that this is a reasonable one, and it is used, therefore, in connection with our examination of the possibilities of improvement.

[1] "The Diesel Engine," by H. Ade Clark, 1903.

[2] "The Limits of Thermal Efficiency in Diesel and other Internal Combustion Engines."

[3] "A Standard Cycle for all Types of Internal Combustion Motor," Inst. C.E.

[4] "Thermodynamic Cycles in Relation to the Design and Future Development of Internal Combustion Engines."

[5] "Report of the Empire Motor Fuels Committee."

[6] "Report No. 205 of the National Advisory Committee for Aeronautics" (Washington, U.S.A.).

[7] "Experiments on the Power and Efficiency of the High-speed Gas Engine," by A. F. Burstall, Institution of Automobile Engineers, 1925.

The mechanical efficiency of quicker running engines of the motor car and aero types reaches, in some cases, 90 per cent. It was felt, therefore, that 85 per cent. should not be too difficult of attainment, even for high pressures, for tests have shown that the loss does not increase with rise in ratio.

With a mechanical efficiency of 85 per cent. and an efficiency ratio of 85 per cent. the fuel per brake horse-power for a 13·25 to 1 compression ratio is 0·3 lb., and if the above assumptions are near the truth, it should be possible to reach a consumption of this order. Table IV. gives these results with different mechanical efficiencies.

The mechanical losses in internal combustion engines are approximately as given in Table V.,[8] from which it is seen that most regard must be paid to the piston rings.

TABLE V.

Suction	1·4 H.P.	3·4 per cent. of I.H.P.
Piston friction	2·5 H.P.	6·1 per cent. of I.H.P.
Other friction (valve lifting, &c.)	1·1 H.P.	2·7 per cent. of I.H.P.
Total	5·0 H.P.	12·2 per cent. of I.H.P.

Though this is well known, and has been several times demonstrated for the C.V. engine, tests were carried out to determine the ring loss with high pressures, and also to find the effect of variations in piston construction, which may be of interest. These results are given in Table VI.

TABLE VI.

Full complement of rings. 4 rings, 1 H.P. scraper and 1 wide scraper.		2 rings and 1 high-pressure scraper ring.	
Revs. per min.	Friction H.P.	Revs. per min.	Friction H.P.
330	11·4	325	10·6
395	14·4	395	13·8
500	22·3	500	20·3
620	34·7	600	29·7
700	47·8	720	44·7

The normal Diesel engine piston is one with a large number of rings, seven or more, and it can therefore, from the foregoing, be safely concluded that considerable losses are occasioned thereby. It does appear, therefore, if the mechanical efficiency is to be raised, that the design must follow the line of motor car or aero practice; that is to say, higher speeds, smaller pistons, fewer rings, &c. Against this, it must not be lost sight of that fluid friction with the higher speed of rubbing of the piston, tends to increase, thus reducing the mechanical efficiency and, therefore, this must also be taken into account.

Gains from savings on other losses obviously cannot be considerable, probably the most important is the use of pressure lubrication throughout, and in connection with this it will be agreed that, apart from any mechanical gain, it is really an absolute necessity for an engine running at the higher speeds; this the investigation seems to indicate, is the avenue of advance. It will be seen that the total saving, made by the greatest care in all these points, should succeed in the end, in obtaining a mechanical efficiency even of 90 per cent. in favourable conditions.

The effect of speed on thermal efficiency is shown by the tests carried out by Sparrow, which indicate that with some engines increasing the compression ratio increases the power loss at low speeds more than at high speeds. The experiments by A. F. Burstall also show conclusively that higher power and efficiency can be obtained from the gas engine by increase of speed, provided that the engine be suitably designed to run at a high speed.

It has also been shown by Burstall that it is possible to run efficiently at very high speeds—say, 2000ft. per minute piston speed—with mixtures as weak as 75 per cent. of the "correct" without using a stratified charge.

Curves are also given in this paper[9] from which it is at once evident that the combustion chamber efficiency of the engine is higher at the higher speeds. This is no doubt due to smaller heat loss, which entirely outweighs any slight drop in volumetric efficiency, and a comparison of the curves shows that, apart from the volumetric efficiency change, the engine is a more efficient heat motor at the higher speeds, and thus should improve on the gains theoretically indicated by previous figures.

Considering now the possibilities of an engine to meet these conditions, we find that in this country the development of the engine using simple liquid pressure injection of the fuel direct, without air blast, through an atomiser into the cylinder and working with compression ignition, has recently been more marked.

This type of engine undoubtedly originated in this country, and works on a cycle approximating to the constant volume, and though now materially different in constructional detail, sprang from Lincolnshire stock. This type seems a useful basis to begin on. When applying the high pressures to design, the parts, in the main, which have to be considered are the outside casing, connecting rods, cylinder covers and bolts, and crank shaft.

By the adoption of cast steel for the main structure, formed as a box or multi-cellular crank casing, adequate provision is made to cover all stresses, even when metal thickness is cut down to $\frac{1}{2}$in. The connecting rod requires but a small percentage of increase as a strut and the cylinder bolts equally so in tension. Generally, the engine could not be made much lighter except by change of material.

For this type the average weight/power ratio is but 15 lb. to 20 lb. per brake horse-power. In an engine of this type, with cylinder diameters up to 18in., a liner of homogeneous hard thin steel allows of great accuracy of manufacture with equality of expansion, and with good cooling, closer piston fits are possible, thus securing continued tightness and ability to carry the higher pressures, with freedom from wear and without any undue material stress under all loads or temperatures; it also maintains this tightness throughout better than the low-speed engine with a large cylinder.

[8] "Indicated Power and Mechanical Efficiency of the Gas Engine," by Professor B. Hopkinson, "Proc." I. Mech. E., 1907, page 863.

[9] "Experiments on the Power and Efficiency of the High-speed Gas Engine," by A. F. Burstall, Inst. of Automobile Engineers, 1925.

With a high-pressure lubricating system throughout, engines running at such speeds will give a degree of reliability no less than that of the slow-speed type itself. The piston and rings are subjected to the high pressures for a much shorter time, and working against a hard steel liner the wear of these parts sometimes found in low-speed Diesel engines is obviated.

In practice it has been found that with quick-revolution engines there is no difficulty in maintaining piston tightness with fewer rings and lighter ring pressures than are usual in the low-speed type. Mechanical efficiency is thereby raised. Higher engine speed also gives another advantage, inasmuch as it permits of the better use of the rapid firing of the constant volume cycle.

With respect to the other mechanical components of the engine, high loading of the big end bearings and crank shaft are found to be factors worthy of consideration, with the high maximum pressures. Though they do not affect mechanical efficiency and can be covered by normal design, methods to reduce them were considered, and two suggest themselves as effecting reduction of loads:—

(*a*) Increasing still further the speed of the engine.

(*b*) Increasing the weight of the reciprocating masses.

On the whole method (*a*) is the most practical and simplest, as increasing the speed besides raising the value of the counteracting inertia forces is accompanied by an increase in power.

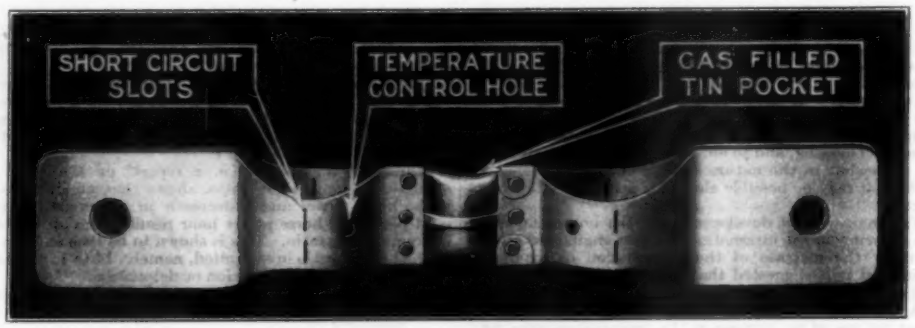
Considering the effect of speed on big end loading in more detail, the curves in Fig. 5 were calculated for an engine having a 12in. stroke and an aluminium alloy piston weighing 17·25 lb., the reciprocating masses being 28·27 lb. The intersecting curves shown are derived from the conditions on the first and third strokes. The figure shows that the maximum loading decreases up to some particular point, in this case where the speed is 1325 revolutions per minute. After this point the maximum loading increases continuously as the speed is increased.

The use of high conductivity material is much more possible in the smaller cylinders of quick-running engines, and advantage can be taken to construct the usually difficult cylinder cover in such material with consequent gain. The stress in cylinder liners is a combination due to temperature and to gas pressure. Investigation of this is carried out in a paper[10] by H. F. G. Letson.

(To be concluded).

An Improved Electric Fuse.

A VERY interesting demonstration of tests of electric fuses took place a few days ago in Manchester with the object of proving the advantages of an improved system of fuse construction called the "Aeroflex," made under Hope's patents by Parmiter, Hope and Sugden, Ltd., Longsight, Manchester. The first series of tests was made at the Polygon sub-station of the Manchester Corporation electricity works, and the second at the works of the above-mentioned firm. At the sub-station the tests were made for short circuits with current at 3540 ampères at 450 volts, while those at the works of the makers were confined to overloading. With the object, presumably, of impressing the visitors, a number of tests were first carried out with ordinary fuses in which copper, tin, aluminium and zinc wire were used, and the effect of short circuiting was demonstrated in an alarming manner. Then there followed a series of tests with different types of fuses constructed on the "Aeroflex" system, from which visitors were able to note that it was possible to have a short circuit under the above-mentioned conditions without the usual alarming results. In fact, without reference to the meter it would have been difficult in some cases to know that the fuses had blown at all.



THE "AEROFLEX" ELECTRIC FUSE

The "Aeroflex" fuse consists of an outer cylindrical casing and an inner casing, the annular space between the two providing an expansion chamber. The only means of communication between the two chambers is a small opening in the inner casing which is normally closed by a paper seal. The inner chamber contains the fusible element—illustrated above—which is surrounded by a filling compound in which the contact stems are also embedded. When the fuse is blown under heavy short-circuit conditions, the gases and a quantity of powder pass from the inner chamber into the outer one by way of the opening referred to above. There being no vent of any kind in the outer chamber, no escape of gas or flame is possible, and the fuse can therefore be safely blown in earthed iron cases without linings or protection of any kind. The fusible element is a special strip made of copper, the centre part of which is reduced in area and supported by a tin pocket. This pocket, when the fuse melts from overload forms a subsidence chamber in which the low melting metal collects. It is hermetically sealed and filled with carbon di-oxide gas under pressure. When the fusible element is blown as a result of a short circuit, the centre tin pocket is seldom involved, and the actual rupture occurs in the copper at either end. The construction of the copper strip provides two points at which the fuse can rupture, these two points occurring at the narrower sections, while the action under short circuit is further made absolutely definite by the provision of slots at the narrowest parts. The position and size of these slots have been very carefully determined, and result in an accurate and definite cut-off when on short circuit.

The control of the overload capacity or normal blowing load of the strip is effected by a hole drilled in the strip between the slots above referred to, and the pocket. Any increase in the size of this hole results in the reduction in the carrying capacity of the fuse, so that the opening-out of the hole provides a means of adjusting the fuse rating to suit any special requirements. As previously mentioned, on short circuit the centre tin pocket is rarely involved in the fusing, whereas on overloads this low-melting metal fuses first and the final blowing takes place on the narrow copper connecting paths. The carrying capacity of the fusible element is controlled by the temperature of the copper strip, and this carrying capacity is varied by merely opening out the small holes on either side of the centre portion, so allowing sufficient heat to be generated in the fusing chamber to melt the tin pocket.

The "Aeroflex" fuses are made to comply with the Admiralty's specification for standard packed fuses. The temperature tests at the maker's works were very severe. A 1500-ampère fuse after four hour' run on full load blew at 2000 ampères, and opened the circuit under four minutes from the time of application of the increased load. In order to overcome the objection that might be raised that there is no possibility of tracing a blow, the makers have provided an indicating device on some of their fuses, consisting of a light wire on the outside of the casing, which acts as a minor short circuit and gives luminous indication when the fuse has blown.

[10] "The Temperature Distribution and the Thermal Stresses in a Diesel Engine Liner," "Proc." I. Mech. E., 1925, page 19.

WATER-POWER DEVELOPMENT IN SWITZERLAND.

A REPORT on the utilisation of the water power of Switzerland, published in the *Schweitzerische Wasserwirtschaft*, has been reproduced or summarised in more accessible journals, and the following particulars relating to the years 1923 and 1924 and the work in progress in 1925 are taken from the January, 1926, issue of *L'Industrie Electrique*.

In 1923 the total output of Swiss hydro-electric power plants was 3095 millions of kilowatt-hours: utilised, for power, lighting and heating, 1714 millions; by railways, 280 millions; and in electro-chemistry and electro-metallurgy 580 millions. More than 10 per cent., or 321 millions, were supplied to neighbouring countries. The consumption per head was 650 kilowatt-hours. Private and State enterprises paid an average dividend of 5·75 per cent., communal undertakings, 11·7 per cent., the range being from 4·1 to 64·5 per cent.

In 1924, in which year the station of Wäggital was put into operation, the power installed was increased by 118,000 horse-power, the total at the end of the year being 1,750,000 horse-power. The Cantons having the largest totals of power plant installed were:—Berne, 398,000 horse-power; and Valais, 308,000 horse-power. The output reached 5000 millions of kilowatt-hours; 888 million in Valais and 717 million in Berne.

The classification of power stations showed:—Private and co-operative, 753,977 horse-power, or 48 per cent. of the total; municipal, 233,420, or 15 per cent.; cantonal and State, 399,482, or 25 per cent.; Federal (railways), 185,500, or 12 per cent.; total, presumably the average for the year, 1,570,377 horse-power.

At the end of 1924 ten large power stations were being built, and others enlarged, and these will provide an additional 407,000 horse-power and 720 million kilowatt-hours, and the totals for the country, when these plants are in operation, will be 1,977,000 horse-power and 5820 million kilowatt-hours, or just over two-sevenths of the 20,000 million estimated as available in Switzerland.

Plans are ready for the construction of a number of large power stations; in the region of the Rhine, four; of the Aar, four; of the Limmet, one; and of the Rhone, two; and the estimated output is 2600 million kilowatt-hours. The area of Switzerland is a little less than 16,000 square miles, or not much more than 2¼ times that of Yorkshire.

INSTITUTE OF TRANSPORT.—The Council of the Institute of Transport has arranged for examinations for candidates for admission to graduateship and associate membership of that Society to be held on April 15th and 16th next at the following addresses:—London: King's College, Strand, W.C. 2; Manchester: High School of Commerce, Spring-gardens; Leeds: The University.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Trade Suppressed by Obscure Outlook.

INDUSTRIAL activity in some of the Midland and Staffordshire industries has been quickened by the arrival of the spring season, but while the question of the coal supply remains in suspense and the further issue in the engineering trade is unsettled, the expanding demand which iron and steel-masters expect in the spring is suppressed. The coal disturbance, although a little more remote than that of the engineers, is also retarding business, makers restricting their contracting to the period for which coal supplies are reasonably assured. Apart from these special anxieties trade appears to be fairly healthy. Local steel works are busier than they were, and the ironworks are also rather better off for business. Although there has been a falling off of inquiries in the structural branch of the market, orders for this class of steel have been placed in good volume since the beginning of the year, and a large number of schemes are known to be suspended, which will inevitably find additional work for the steel mills when labour troubles are out of the way. A lot of finished material is wanted by the railway companies, and such industries as the motor and cycle trades, edge tool trades, &c., are good customers for steel. Buying of material is, however, restricted to current or immediate requirements. Instances of buying forward are rare. Rather heavy lots of foreign material, like iron and steel, are coming into this district, but most of these shipments are in fulfilment of old contracts.

Steel Business.

In steel, business moves within very restricted limits, and participation in the orders given out depends largely on acceptance of rock-bottom prices. Price-cutting continues to be acute. The market in bars, as reported last week, has definitely slackened, and £7 15s. is now the generally quoted price. Angles and joists range from £7 to £7 5s., with tees 20s. more. Ship, bridge and tank plates are procurable at £7 15s., and boiler-plates at £11. The £10 10s. figure for Staffordshire hoops continues to be cut by some unassociated houses. Mild steel billets sell at £6 upwards, but an increasing quantity of Belgian semis at from £5 6s. to £5 10s. per ton is being worked up in Staffordshire works. Steel scrap is selling rather more freely at £3 7s. 6d. to £3 10s. delivered South Wales. Lower prices are being accepted for continental finished material. Joists, untested, can be bought at £4 17s., a reduction on recent figures of 2s. per ton. Bars, plates, &c., are also cheaper. The case is different with regard to semi-finished material, which, if anything, is rather firmer, Belgian quotations ranging up to £5 10s., though deliveries are somewhat more expeditious. Engineers, the chief users of steel, are deterred from enterprise by the possibility of a crisis in either, or both, the coal and engineering trades.

Finished Iron.

There has been no change in the finished iron trade in this district during the week. Though the mills are a little better employed, business is extremely patchy and values are unsteady. Makers of marked bars are not well off for orders, many engineering projects being held up pending the outcome of the threatened labour troubles. Values remain on the basis of £14 per ton. Crown quality bars have again this week been sold in special cases at rather less than £11 5s. Lancashire mills quote £11 for export. South Africa is the main support just now of the overseas trade. At home trade remains quiet, no commitments being entered into which can be deferred. Good orders could probably be placed by home consumers of nut and bolt and fencing iron at £10 2s. 6d., if there were any occasion for big purchases. Both Staffordshire and Lancashire houses quote £10 5s., but that is not regarded as the irreducible minimum in the case of Lancashire bars. Many Staffordshire mills do not think it worth while to compete on cutting terms, as the orders given out are extremely meagre, with Belgian bars at £6 15s. Fairly large quantities of this continental material are coming into the Black Country, but for the most part they are in fulfilment of old contracts.

Pig Iron.

Pig iron buying is, for the most part, restricted to April requirements, owing to the uncertainty of fuel supplies after the subsidy period. Smelters are not, however, stocking heavily, despite the fact that blast-furnace coke is actually cheaper than at any time since the year opened. It would seem that the threatening situation in the engineering industry is as serious a deterrent to business as the coal crisis. Between them, they discourage all bargaining outside immediate needs. There is little prospect of freer conditions for some time to come. Many furnaces in blast are producing as little as possible. The slow subsidence of pig iron prices continues. There is no general marking down, but the exceptional rates which some smelters have been ready to accept rather than incur the danger of stocking tend to define a new level as days go by and the market receives no fresh stimulus. Forge qualities are reported to have changed hands at prices appreciably lower than those quoted. The amount of business done, though better than for some months past, is still insufficient to give the market a real price level. Northamptonshire forge ranges from £2 16s. to £2 17s., Derbyshire from £3 to £3 2s. These prices are 1s. to 2s. per ton lower than those generally acceptable a week ago. Smelters are finding it extremely difficult to do business in foundry grades at recent rates. With the prospect of an order running into a good tonnage, there would appear little doubt that concessions would be made. Northamptonshire No. 3 foundry is obtainable at £3 3s. 6d. upwards, and Derbyshire at £3 6s. 6d. at furnaces. East Coast hematite is about £3 15s. for mixed numbers at furnaces. Blast-furnace coke is 6d. to 1s. per ton cheaper. This seems to indicate a belief that the chances are all against an interruption of supplies.

Galvanised Sheets.

The galvanised sheet trade is busy, with a steady arrival of new orders from most foreign markets. While the usual quotation for 24 corrugateds is £16, that figure is shaded in some cases. Other mills, however, want £16 5s. per ton, and these makers will not vary the figure.

The Trade Returns.

That there was more activity in iron and steel last month than in January is evidenced by the trade returns, but it is noted that while we exported more material we had resort to an increased amount of foreign supplies to enable us to do the business. The export tonnage was just under 3000 tons better than during the previous month, but our imports were nearly 7000 tons more than in January. The bulk of these imports came from France, Belgium, and Germany. Imported forge and foundry pig amounted to 7530 tons, against 6186 tons in January; basic pig to 16,425 tons, against 12,803 tons. The exports of pig iron in February totalled 35,534 tons, more than two-thirds of which was of forge and foundry qualities. While the tonnage was worse than it was a year ago, it was better than the figure two years ago. Shipments of ingots went up from 4583 tons to 8130 tons. Steel blooms, billets and slabs were sent in less freely than in January, when 53,289 tons were imported. The total for February was 44,432 tons, 16,000 tons less than two years ago. Imports of iron bars, rods, angles, &c., also declined. Last month they aggregated 15,821 tons, as compared with 20,342 tons in January. Trade in foreign steel girders, beams, joists, and pillars was of appreciably smaller proportions than those of a year ago, but the February imports, 8203 tons, were larger than those for January. The imports of hoops and strips almost doubled, jumping up from 5322 tons in January to 10,221 tons last month. Midland iron and steel masters consider it poor consolation that foreign markets can only be held by buying from the Continent such a large proprtion of the crude metal and half-products that enter into our finished goods.

Birmingham Quarterly Meeting.

Owing to the Easter holidays the Quarterly Meeting of the iron trade on the Birmingham Exchange, due on April 8th, has been postponed until April 15th.

Rolling Stock.

Midland rolling stock firms continue fairly well employed, and additional contracts continue to be received both from home and foreign railways. This week's announcement that the Birmingham Carriage and Wagon Company, Ltd., has been awarded a contract for six new sleeping coaches for the Buenos Aires and Pacific Railway Company, Ltd., has given considerable satisfaction, for had it not been for the demands for material to carry out contracts secured by such establishments as these the Midland, and Staffordshire in particular, iron and steel works would have been in a worse position than they are to-day.

Obituary.

I regret to have to record the death, which took place on Friday last, of Mr. James McDougall, chairman and managing director of the firm of James McDougall (Limited), Hope Patent Tube Works, Wednesbury. Mr. McDougall, who was seventy-three years of age, was well-known on the Birmingham Exchange, of which he had been a member for a large number of years. He was a member of the Birmingham Chamber of Commerce, and had a large circle of friends, by whom he will be much missed.

Unemployment.

The unemployment position in the Midlands continues satisfactory, the number of workless in the area continuing to decrease. The latest returns show that the total unemployed number 112,117, or 2670 less than the total at the end of the previous week, and 5937 less than a fortnight earlier. A slight drop is also recorded in the numbers on short time. The number of totally unemployed in the Birmingham area now stands at 21,622; Bilston, 2035; Coventry, 1165; Cradley Heath, 3686; Derby, 1925; Dudley, 2678; Leamington and Warwick, 437; Leicester, 2095; Northampton, 1624; Nottingham, 6541; Oldbury, 900; Peterborough, 375; Redditch, 1054; Smethwick, 2860; Stoke-on-Trent area, 12,665; Stourbridge and Brierley Hill, 3180; Tipton, 1408; Walsall, 4305; Wednesbury, 2113; West Bromwich, 2589; Wolverhampton, 4287; Worcester, 1472. Of the total of 112,117, 81,445 are men, 1223 boys, 26,594 women, and 2855 girls.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

General Outlook.

THE spurt in buying operations which the Lancashire iron and steel trades were looking for with a settlement of the dispute in the engineering industries has so far not made any sign of its appearance. Naturally, the tone of the markets here is perhaps a little brighter than it has been for some weeks, but beyond that there is not up to the present justification for anything more cheerful to be said. For one thing, the way is not yet clear for the free transaction of forward business. The coal trade uncertainty is again prominent as a cause of apprehension. Both manufacturers and users of iron and steel materials are inclined to await developments in this direction before entering into commitments for future delivery, the result being that the general run of business is for prompt or early delivery and is not extensive in character. The state of the engineering industries themselves in the Lancashire area is not sufficiently active to warrant heavy buying of raw materials, although it is probably true to say that the position on the whole is not so bad as the present volume of purchases would lead one to assume. Most of the textile machinery makers are moderately busy, although the home demand for machinery of this class is very quiet, owing to the unfavourable position of the cotton industry, whilst fresh export inquiry also has been smaller during the last month or so. Locomotive and wagon builders are better situated as the result of the contracts recently placed, and the electrical firms on the whole are fairly active. The machine tool trade, however, is busy only in patches.

Non-ferrous Metals.

The rather uncertain outlook in the case of copper, with heavier unsold stocks at American refineries and the prospect of still further additions to these during the present month if the consumption in Europe remains at its present level, does not make for steadiness in prices. The demand on this market is no better than it has been at any time during the last six weeks or so, but neither is it any worse, consumers apparently taking just enough to satisfy early needs and no more. Copper sheets are unchanged at £90 per ton, with the basis prices for copper and brass tubes and condenser tubes still quoted at 1s. 1d., 1s. and 1s. 2½d. per lb delivered. Spelter has been fairly well maintained in spite of the lull in buying, and it is believed here that higher quotations may follow any improvement in the demand for this metal. Tin is a good deal lower now than the highest point touched last week, but there is not much doubt that the statistical position remains very strong, and a gradual advance may be looked for again before long. The demand for lead on the Manchester market has been quiet in most directions and quotations are distinctly easy.

Iron.

There are few developments to report on this market this week. A resumption of inquiry has been experienced in some sections, but it is by no means extensive, and business that is being booked now is usually of a hand-to-mouth nature. As was pointed out last week, however, those makers who are selling on the Lancashire markets are fairly busily engaged on orders in hand, and that will probably keep plants going for at least another couple of months. In some cases there is a feeling that the pig iron market is easier than it has been, but from what one can see values all round seem to keep pretty steady; at all events, there is not sufficient change in prices to signify any real weakness. Derbyshire No. 3 iron is still offered at the range of 75s. to 76s. 6d., according to make, with Lincolnshire and Staffordshire at 76s., and both Scottish No. 3 and West Coast hematite at about 94s. per ton delivered Manchester. For forge iron the demand just now is quiet; for delivery into this area Lincolnshire is quoted at 72s. 6d. per ton and Derbyshire at about 1s. more than this, although these prices are regarded as being more or less nominal. Lancashire bar iron is only in moderate demand, both for home use and for shipment, with Crown bars quoted at £11 7s. 6d. per ton and second quality at £10 5s. delivered.

Steel.

So far as steel is concerned, business actually put through has been of small compass, and, as in the case of iron, has been of a hand-to-mouth character. The only inquiries of any moment that have been circulating during the last few days were one for constructional steel and another for what was described as a fairly big parcel of plates, but there is no evidence as yet that there has been any actual business of importance. There is no doubt that prices in this market are weak, although nominally quotations show little change. Plates, for example, are quoted at the range of £7 12s. 6d. to £7 15s. per ton, and whilst some firms say that the former figure is out of the question there are others who are prepared to accept it for any quantity. Joists and angles are on offer at about £7 2s. 6d., and bars at £7 17s. 6d. to £8 5s. per ton, delivered Manchester or equal. The demand for galvanised sheets is still quiet, and only a few small parcels have been disposed of this week for India at easier prices, while offers now being received from that market are as low as £15 10s. per ton f.o.b. In the hope of stimulating the demand from the Far East, a reduction of 10s. per ton in the basis price of thin gauges has been made; cuts are also announced in quotations for galvanised sheets for the home markets. There is some business being done in continental steels on this market, but it is by no means important, the price advantage being discounted to a very large extent by the delivery factor, as users are showing no disposition in this case either to commit themselves too far ahead. All lines of continental finished and semi-finished steels are easy, and in some instances values are slightly lower than they were last week. For net cash against shipping documents and including delivery here, joists range from £5 15s. to £5 17s. 6d.; steel bars are at about £6 4s.; sheet bars at £5 7s. 6d.; ordinary plates at £6 10s.; Siemens plates at £6 15s.; and Belgian iron at £6 10s. per ton.

Scrap.

The demand for ferrous and non-ferrous scrap is slow pretty well all round, and prices are easy in most cases. Wrought iron is being quoted at 65s. to 67s. 6d. per ton, textile machinery scrap iron at about 72s. 6d., and ordinary machinery scrap at 70s., all delivered to users' works, whilst mild steel is about unchanged at 55s. on truck Manchester. For graded qualities of non-ferrous metal scrap cast aluminium is quoted at £91 to £92; lead, £32; zinc, £24 10s.; braziery copper, £49; heavy copper, £60; and gun-metal, £53 per ton, delivered to consumers' works.

Institution of Mechanical Engineers.

There was a very large attendance of members of the North-Western Branch of the Institution of Mechanical Engineers and kindred societies, as well as ladies, to hear Sir Henry Fowler deliver his old chief, Sir John Aspinall's, Hawksley Lecture at the College of Technology,

Manchester, on Thursday, March 18th. Papers or lectures which have for their subject railways or locomotives are always certain to attract in this district, and the present contribution was no exception. In spite of the absence of the lantern illustrations which Sir Henry had omitted to bring with him, the lecture, with the additional parenthetical remarks of the reader, was listened to with great interest. It was followed by the cinematograph film of the proceedings at the Railway Centenary, which was made at Darlington last June. The film had been previously shown in Manchester by Mr. Gresley, when he read his paper before the North-Western Branch of this Institution on "Three-cylinder Locomotives," and although the film showed signs of wear, it was well worth seeing for a second time. At the conclusion of the lecture a vote of thanks to Sir Henry Fowler was moved by Alderman F. J. West, ex-Lord Mayor and chairman of the College of Technology.

The Threatened Lock-out.

Much relief was felt in the Manchester district when the news came through on Thursday evening last week announcing the withdrawal of the lock-out notices in the engineering works. Unfortunately, the announcement was received too late to prevent the paying up of the men who had in nearly all cases ceased work. Interference with work in the shops next day was, however, minimised by the wireless announcements of the British Broadcasting Company that work would be resumed next morning as usual, and the number of hands who did not "turn in" was only small.

Orders for Uniflow Engines.

Orders were received last week by Galloways, Ltd., Manchester, from the Llanelly Steel Company for two uniflow engines. One of these engines has a cylinder, 48in. diameter by 48in. stroke, and will be capable of giving 1800 indicated horse-power at 100 revolutions per minute. This engine is intended to drive a sheet mill through a rope fly-wheel on the mill shaft, 36ft. diameter and 165 tons in weight. The second engine is of the slow-speed uniflow type, with a cylinder 27in. diameter by 42in. stroke. It is for direct coupling to cold rolls, and the speed is 48 revolutions per minute.

BARROW-IN-FURNESS.

Hematite.

The hematite pig iron trade in the North-West District continues with little variation, either one way or another. It has not assumed the proportions which some expected it would, but, on the other hand, it has not fallen away as was predicted by others. It might move one way or another, and the general opinion is that if we can get industrial peace there are great hopes that it will improve considerably. The output is being fairly well cleared, what with the requirements of the steel departments in the districts and the deliveries to customers. There is marked tendency on the part of customers to take only such tonnage as will keep them supplied for the time being. Trade is heaviest with the Midlands. The business being done with the Continent is not large, but last week there were two cargoes of pig iron to Treport and one to Antwerp. This business does not mean a revival of trade with France and Belgium, for the value of the franc precludes such a development at the present time. American trade still exists, and there was a dispatch of iron from the Barrow, Ulverston and Millom works to Philadelphia. This iron is of semi-special quality.

Iron Ore.

The iron ore trade is only moderately engaged, and the trade is mostly on local account. What tonnage is going out is very small and an improvement is not expected for some time. Cumberland is the most active district, but at none of the mines is there anything like full activity. Foreign ore is being imported in moderate quantities from the various sources, but the tonnage is being kept well within bounds.

Steel.

The steel trade is not very bright, and there are not sufficient contracts to keep the two steel plants in full work. At Workington full time is not being worked. At Barrow the rail mills are better situated at present, but fresh orders are needed. A share in the order for fish-plates for the London and North-Eastern Railway came to Barrow. The small section and hoop mills are kept going regularly.

Engineering.

It is good news that the International Combustion Company has booked orders which will result in more employment at its Barrow works, which adjoin Vickers' establishment, and which during the war were used for the production of shells. Since the International Company, in which Vickers are interested, took over the works at Barrow, there has been a steady growth of activity and a gradual increase in the number of hands employed.

SHEFFIELD.

(From our own Correspondent.)

The Heavy Steel Trade.

THE unsatisfactory condition of the commercial steel trade continues. The demand for raw and semi-manufactured materials has recently shown a tendency to shrink further, and the melting furnaces are not at all well employed. Now that the danger of an engineering lock-out is out of the way, however, it is probable that conditions will improve. There is a rather better call for shipbuilding steel, and the heavy forges and steel foundries have lately booked increased work for locomotive and other high-class engineering parts. The fully manufactured side of the heavy trade is better employed than that which sells its products in a partially finished state. This better state of things is seen chiefly in the railway steel departments, which have recently received orders from the home companies, for axles, tires and springs, on an unusually large scale. The departments are far from fully employed, however, owing to the fact that they are still receiving only a moderate share of work from overseas, particularly from India and South America. The bulk of orders from those sources still go to the Continent. A few contracts have been obtained in this country, but at unremunerative prices. Henry Bessemer and Co., Ltd., one of the oldest firms engaged in the railway steel industry in Sheffield, did better last year than the year before, and report a net profit of £1306, as against a loss of £6572. They state that the present year opened with a good order book as regards volume of orders, but prices still continued low. The firm is installing a new tire plant, some parts of which are already at work. The buildings are finished; the cranes, one of the new hammers, electric equipment and tire mill are installed.

Other Steel Branches.

The wire rope trade is well employed, and there is considerable activity in high-grade wire, steel strip and sheets, stainless steel and iron. The ironfoundries are very quiet, except in the matter of stove grates. The crucible steel trade is unfavourably situated. There were signs of improvement in the early part of the year, which brought an increased trade to some of the smaller firms, but they now report that activity has fallen off. The unsatisfactory state of some of the old staple trades continues, such lines as files, edge tools, and other kinds of hand tools being severely depressed. As these branches are not affected by foreign competition, the quietude is difficult to account for. The position is a serious one, as many firms engaged in the finished trades are working without profit, while some are actually losing money. At a dinner of the Sheffield Trades' Technical Societies last week, the suggestion was thrown out that the lighter trades should enlist the support of the Cutlers' Company, the Chamber of Commerce, the manufacturers and trades unions, that they should hold competitions for workmen, and that the products of their skill should be publicly exhibited in order to advertise the crafts of Sheffield. The Senior Warden of the Cutlers' Company expressed the opinion that that body would give its hearty and practical support to any project for the maintenance and upbuilding of the trades.

Cutlery and Plate.

These trades will be glad of any assistance that can be given them by a combined campaign, for they are at present, and have been for some time, under a cloud of depression. The making of stainless table knives is still the busiest department, but even in this there has been a great falling off during the year. A few good orders are on hand for large supplies of table ware for hotel, railway and steamship equipment, but apart from these trade is very quiet. The quantity of goods distributed through the ordinary shopkeeping channel tends to fall off, and it is threatened with further restriction as the result of the cash-on-delivery scheme which is to be put into operation by the Post Office. The system will probably improve the trade done by great departmental stores, mail order houses, and manufacturers who deal direct with the public. There are at present few of the latter in Sheffield, and most of the firms are so loyal to their shop-keeping customers that they would refuse to execute an order from the consumer direct, even if it were accompanied by cash. Some of them, who consider that shopkeepers are at present charging excessive profits, may take advantage of the new system.

The Merchandise Marks Bill.

The Government Bill for the amendment of the Merchandise Marks Act is not received with any enthusiasm in Sheffield, where it is not considered that the proposals go far enough to be of any material advantage to the local trades. Mr. R. T. Wilson, Law Clerk to the Cutlers' Company, in a report which he has prepared for the Chamber of Commerce, points out that the vital defect in the Bill is that there is no provision that requires that any imported goods, except foodstuffs, should be marked before they pass through the Customs. One section lays it down that "imported goods" do not include "goods which since the date of their importation have undergone a substantial change by reason of manufacturing process." This, says Mr. Wilson, would enable German scissors "blanks" to be brought into this country, and then hardened and ground and sold as English without any indication of origin being required. Similar criticism of the Bill has been offered by the Sheffield Cutlery Council, which has expressed keen disappointment that no provision is made for a mark of origin to be placed upon all manufactured articles imported into this country. Without this provision the Bill is, in its opinion, of little use to the lighter trades of Sheffield.

Colliery Matters.

Capital progress is reported from Firbeck Main, one of the latest collieries to be sunk on the eastern extension of the South Yorkshire coalfield, and one of the outstanding examples of rapid development. It is less than a year since the Barnsley seam was proved in No. 2 pit, at a depth of 825 yards, but it was possible to place the coal on the market at once in a proper condition, as the screens were ready for operation. The headings through the shaft pillar have made good progress and the regular working of the seam has begun. The screens, gantries and washeries have been finished, and the general equipment of the colliery is nearly completed. It is expected that the construction of the branch line of railway to the colliery will also be completed within a short time. At Rossington Main, the new coal washery is ready for work, and will form a valuable addition to the plant. No. 1 pit has also been completed for coal winding. A matter of much interest to colliery engineers is the decision of the Midland Institute, the South and West Yorkshire Coal-owners' Associations, to undertake a thorough investigation into the whole question of the underground conveying and loading of coal by mechanical means. The object is to bring about an improvement in the output per man employed. A special committee has been appointed, consisting of representatives of the three bodies, which will visit other districts, and if necessary other countries, in order to inquire into the latest practice. The committee will consider the most suitable and reliable machinery for the very varying conditions that are met with; it will pay special attention to the organisation and supervision necessary for obtaining the best results, and it will very carefully consider the question from the point of view of safety.

Some Orders.

Kitson and Co., Ltd., of the Airedale Foundry, Leeds, have received from the Cordoba Central Railway Company an order for five 4–6–2 type superheater engines and double-bogie tenders. Among the firms with which the London and North-Eastern Railway Company has placed orders for 1910 tons of steel fish-plates is that of Cammell Laird and Co., Ltd., Sheffield. The Highways Committee of Grimsby Town Council recommends the acceptance of the tender of Sir William Arrol and Co., Ltd., Glasgow and Newcastle, for the construction of the new bridge over the Alexandra Dock cutting. The contract price is £54,511. There is at present an antiquated swing bridge, and it will be replaced by the new structure, which is to be a bridge of the lifting type, similar to the one at Keadby.

Goole's New Gasworks.

The work of installing a new plant at the Goole gasworks, at a cost of £31,000, has made very good progress. The installation includes a retort house, with twenty-four retorts, each of which holds 1700 cwt. of coal, to be carbonised in twelve hours, and also a Telpher plant, by means of which coal is obtained direct from canal barges and conveyed to the retort house. Both these features of the plant are expected to be completed in a week or two. There are also to be four new purifiers, 22ft. square, on a ferro-concrete structure, which will be available at midsummer. The new plant will provide 500,000 cubic feet of gas per day, as compared with the 440,000 cubic feet of the existing plant. It is intended to take part of the old plant down at an early date, and extend the new equipment so as to increase its daily capacity to 750,000 cubic feet.

Scarborough Waterworks Extension.

At Scarborough a Ministry of Health inquiry has been held into the Corporation's scheme for extending its waterworks at a cost of £70,000. The works include the sinking of a well and erection of a new pumping station at Irton, and the construction of a new service reservoir at Spring Hill, and are calculated to add 2¼ million gallons to the present daily supply.

NORTH OF ENGLAND.

(From our own Correspondent.)

Cleveland Iron Trade.

SUSPENSE over the outcome of the coal crisis still tends to hold up business in the Cleveland pig iron trade. Inquiries are resulting in few actual sales which suggests that they are circulated more for the purpose of testing the market than for placing orders. Apathy, in fact, characterises every branch of the trade. Makers are still firmly refusing to make price concessions, and affirm that a withdrawal of the coal subsidy can only mean still higher prices for iron and steel. Be that as it may, buyers are inclined to operate with caution, and business is mostly of a hand-to-mouth character. However, industrial needs must be met, and small orders continue to come in to supplement fairly large unexecuted contracts, which are still on makers' books. It is a remarkable fact that in recent weeks, despite the lull in new business, makers' stocks of iron have steadily dwindled, and they are now lower than for many years past. Thus makers are in a relatively strong position, and it is interesting to note that last week's shipments of pig iron from the Cleveland district exceeded 9000 tons. Of that 3000 tons went to America, but there is still little business with the Continent, although the fall of the Belgian franc has introduced another disturbing factor. Prices are unchanged, home quotations being:—No. 1 foundry iron, 72s. 6d.; No. 3 G.M.B. Cleveland pig iron, 70s.; No. 4 foundry, 69s.; and No. 4 forge, 68s. 6d. All export orders are quoted 6d. per ton above the foregoing prices.

Hematite Pig Iron.

There is little change in the position of the East Coast hematite pig iron trade. A fair amount of business is being done, but competition is very keen, and 77s. per ton is rather a sellers' price for mixed numbers, with No. 1 at 77s. 6d.

Ironmaking Materials.

Although imports of foreign ore continue on a heavy scale under running contracts, new business is almost negligible: Best Rubio is nominally quoted at 21s. 6d. per ton c.i.f. Tees. Good Durham furnace coke is still on offer at 19s. per ton delivered at the works.

Manufactured Iron and Steel.

Business is on a very moderate scale in the manufactured iron and steel trade, the general disposition of buyers being only to place sufficient orders to cover immediate needs. As a result, there is a greater difficulty in arranging rolling programmes, and some of the mills are only working intermittently. A gleam of hope is, however, inspired by a slight turn for the better in the shipbuilding trade. North-East Coast firms expect to book further orders for vessels, and a return to anything like normal activity at the shipyards would speedily have a beneficial effect on the iron and steel trades generally. As a consequence of the fall in the value of the Belgian

franc some of the makers of semi-steel abroad have withdrawn offers of material, but there are still heavy imports of blooms and billets into this area. Prices generally are unchanged.

The Coal Trade.

There is a marked disinclination to do business in the coal trade. That has been the position on the Northern coal markets ever since the publication of the Coal Commission report. Any business that has been possible has been confined entirely to the present month, because of the difficulty of telling what the position will be with regard to the subsidy. The outcome of the conferences between the coal owners and miners is awaited with close interest, but the more immediate concern of exporting districts like Northumberland and Durham is to know what the Government intends to do in respect of the subsidy. Should it, in accordance with the Commission's recommendation, cease at the end of April, prices will undoubtedly harden. Another effect would be the closing down of many of the collieries in Northumberland and Durham, as it would be impossible to carry on under such conditions. Should the subsidy continue, as is hoped in many quarters, prices would remain more or less unaltered. In the meantime foreign buyers are not making any move to secure supplies, and this holding up tendency leads to easing of prices for the time being. The Northumberland steam coal section shows no new feature. Best Blyth steams are rather well offered second-hand at 16s. 3d., but producers are very reluctant to operate at less than 17s. There are plenty of other steam coal qualities. Tyne primes are obtainable at 15s., with seconds at 14s., although direct sellers ask recent quotations. Steam small coals are weak for all positions, and sellers are numerous. Bests range in value from 7s. 6d. to 8s., seconds at 7s. 3d., and specials at 10s. While some of the Durham coal fitters have booked up fairly favourably for March, the majority of them are poorly off for orders, and any offers of trade at slight discount prices are snapped up with alacrity. Best gas coals are moderately well maintained at 17s. 6d. to 18s. The tone is easy and unchanged for coking coals at 14s. 3d. to 14s. 9d., according to quality. Bunkers, likewise, are only nominally unaltered, the tendency being disappointing for bests at 15s. 6d. to 16s. 6d., and ordinary kinds at 14s. 6d. The coke trade shows no improvement, and supplies are in abundant offer, with prompt positions, in fact, hardly assured. Prices are weakly held at 20s. to 21s. for gas cokes, 18s. to 21s. for foundry descriptions, and 27s. to 30s. for beehive qualities.

SCOTLAND.

(From our own Correspondent.)

Quiet and Unchanged.

NOTHING has occurred during the past week to alter the outlook in the steel, iron, coal and allied trades, and markets generally continue without appreciable change. A cautious spirit is apparent in dealings of all kinds, neither buyers nor sellers being at all anxious to take the slightest risk of a turn of the market either way.

Pig Iron.

To say the least of it, the market for pig iron is most disappointing. Meagre transactions indicate a lack of confidence with regard to the future. Orders are confined to the smallest possible requirements, and prices are barely steady.

Steel.

Steel makers report that there is keen competition for business in plates and sections, and that the difficulty in keeping mills employed is still very considerable. The prices of ship plates and sections are nominally unchanged, but in all probability a lower price would be conceded by some makers if a good order was in prospect. The current demand for boiler plates is very moderate.

Steel Sheets.

Steel sheet makers have little to grumble at so far as light sheets are concerned. Black and galvanised light varieties continue in active demand; in fact, some makers state that they were never busier nor sold so far ahead in the course of their experience of the trade. The position as regards sheets of special quality is distinctly encouraging. Heavy sheets are not so well booked, and makers of these complain of considerable competition from platemakers.

Bar Iron.

The course of business in the bar iron trade offers no encouragement to makers. Considerable improvement is necessary before the outlook could be termed even moderately satisfactory. In the re-rolled steel department a larger turnover is reported, but home and continental competition continues keen and the prices obtainable are barely remunerative.

Coal.

The depression in the coal market is unabated, and no real improvement can be looked for until the uncertainty which exists as to the future is removed. Shippers are booking foreign business in restricted quantities only, and the collieries are in need of orders for all descriptions. Foreigners are not disposed to pay the prices now asked for forward delivery, and exporters do not feel justified in buying ahead under present conditions. Many shippers are still slow to take up fuel contracted for in the early part of the year, and collieries are endeavouring to dispose of as much of this fuel as possible at the best price obtainable. Even then holders suffer considerable loss when the highest current prices are compared with the quotations ruling in the latter part of January. During the past week aggregate shipments amounted to 267,028 tons, against 211,421 tons in the preceding week, and 207,792 tons in the same week last year.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Position.

SHIPMENTS of steam coal continue on a fairly heavy scale, and last week the returns were the highest for a month, notwithstanding the fact that tonnage at the disposal of the collieries left something to be desired, particularly so far as the latter half of the week was concerned. Departures of loaded boats on Saturday were made up by a goodly arrival of steamers, with the result that the docks were well supplied on Monday, with the exception of Swansea and Port Talbot. The demand for tonnage maintains a steady level, but is not pressing. The influx of new orders is not creating any excitement; in fact, new business on the market keeps within moderate dimensions. This may be due to the belief that there will be no strike in this country, and that there is therefore no need to lay in stocks on any great scale, though foreign coaling depôt owners cannot ignore the possibility of there being trouble and making some provision for adequate supplies. Still other consumers will probably hold off as, should the supply of British coal be cut off, they can no doubt cover their requirements in other directions. Near continental business has been very prejudicially affected by the slump in the Belgian and French francs, and is quiet all round. No new inquiry of any account has come on the market since I wrote a week ago, but in the case of the request of the Egyptian State Railways for 150,000 metric tons of large steam coals, it is now known that tenders have to be in at Cairo on April 21st.

Coalfield Items.

Production of coal at the Cambrian pits commenced last week after a lapse of seventeen months. Close on a thousand men were employed by the end of last week. The Gray pit, at Abertillery, reopened for work on Monday after being closed down since October, 1924. This is one of three pits which altogether employed 800 to 900 men, and there is a probability that another of them will reopen shortly. The workmen have decided to work the double shift in order to absorb as many of the unemployed as possible. Expectations had been held that an arrangement would have been come to so as to enable work to be recommenced at Locket's Merthyr Mardy Colliery, Rhondda. Fresh terms were submitted to the workmen on the 1st inst., these being at least equal to those prevailing at neighbouring pits, but the men have ignored the offer of the management, which held good for a week. This company's four pits normally employ 2000 men. At the end of last week the Great Western Colliery Company gave notices to terminate the contracts of 800 of its workmen at the Tymawr Pit, one of the reasons for this step being trade depression. In the anthracite area just over 200 workmen employed at the Pentremawr Colliery, Pontycymmer, which belongs to the United Anthracite Combine, also received notices to terminate their contracts, this being about one-third of the men employed. The 4ft. seam was recently reached at the new pits of the Taff-Merthyr Colliery Company at a depth of 585 yards, and it is expected that coal-winding will be in full swing by Whitsuntide. This colliery is situated midway between Trelewis and Bedlinog. The sinking of the pits has created a record in the mining world, as it was not until August, 1924, that the first sod was cut. The shares in this company are proportionately held by the Powell Duffryn Company and the Ocean Coal Company. Last week the Meiros Colliery, Llanharan, struck a valuable new seam.

Spanish Coal Restrictions.

So far as can be ascertained there has been no fresh development concerning the protests of traders against the Spanish Government's Decree which restricts the exportation of coal from this country to Spain. The Commercial Committee of the South Wales Coalowners' Association has now taken the matter up and has decided to request the Mining Association of Great Britain to make representations at once to the Foreign Office.

Speeding Up Traffic.

As the result of recent visits of Sir Felix Pole, the general manager of the Great Western Railway Company, important steps have been taken for the speeding up of traffic between the collieries and the docks of this district. Elaborate instructions have been issued to the officials and staff, and regulations have been laid down for the abolition of what was known as the "stop and release" system of working. This meant that coal was stopped at the collieries unless it was released by the Great Western Railway Company, but the new provisions give practically an open road for traffic from the collieries to the sidings at or near the docks.

Newport's Claim.

In March last year the Great Western Railway Company agreed that so far as Cardiff, Barry and Penarth were concerned, vessels should be able to change from one dock to another without being called upon to pay double dock dues. The only charge made has been a small locking fee. The members of the Newport Chamber of Commerce at once took the question up and asked for the same concession to be made to Newport, but the company has declined to do so, the reason given being that Newport has a preferential dock rate in one respect and a loss of revenue would be involved. It appears that shippers and those interested in shipping are ready to agree to an alteration in dock dues so as to bring Newport into line with Cardiff, Penarth and Barry, and therefore the Chamber of Commerce of Newport has instructed its representatives on the Joint Committee to continue to press for a concession to be made to Newport on the same lines as at the other three ports mentioned.

Tin-plate Trade.

The announcement is made that an order for 500,000 boxes of tin-plates has been placed by the Asiatic Petroleum Company, Ltd., with certain Welsh manufacturers. This order is for "outsize" plates, and is to be executed over a period of the next two or three months.

Steel Workers' Wages.

The audit for the three months ended February 28th governing the South Wales and Monmouthshire iron and steel workers' sliding scale shows a fall in the average net selling price of steel rails—20 lb. per yard and upwards—and steel tin bars—of all weights—of 10.80d. per ton, which represents a drop of ½ per cent. The sliding scale for the three months ending March 31st stands at 47 per cent., and following the present audit for the quarter commencing April 1st, it will be 46½ per cent. above the standard.

Cardiff Corporation Contract.

The Cardiff Electricity Committee has now given the order for the supply of electrical cables to the Pirelli-General Company, Ltd., which reduced its tender by £673, or 6 per cent. Its original price was £10,869, as against £8818 18s. submitted by a Belgian firm.

Miners' Holidays.

It has been officially agreed that the Easter holidays in the South Wales coalfield shall be Monday, Tuesday and Wednesday of Easter week.

Notices to Steelworkers.

Over 1000 men employed at Baldwin's Iron and Steel Works, Margam, Port Talbot, have been served with notices to terminate their employment in twenty-eight days.

Current Business.

There was not a great deal of business in steam coals during the past week. For one reason the collieries are very fully booked for this month and the early part of next, and prices are very well maintained notwithstanding that in some cases collieries are disappointed in the amount of ready tonnage at their disposal. On the whole, there has been little change so far as large descriptions are concerned, but smalls have become scarcer and are certainly firmer. Patent fuel is also well booked up. Anthracite coals are still on the quiet side. Pitwood, which, after the termination of the strike at the French Bay ports, fell rapidly to as low as 22s. 6d. to 23s., is now recovering slightly and is about 23s. to 24s.

CONTINENTAL PRODUCTION OF IRON.

THE Paris newspaper *Excelsior*, speaking, in a recent issue, of the conference which was recently held in Paris between representatives of the great iron industries of France, Great Britain, Belgium, Germany, Luxemburg and the Sarre, pointed out that the negotiations were then limited to a preliminary exchange of views, but that they would be resumed after Easter. Two distinct questions were, it was stated, under discussion, the first of which was the re-establishment of the organisation dealing with the distribution of iron rails. Three groups had been constituted:—The Franco-German—including the Sarre—Anglo-American and Belgo-Luxemburg. These three groups would divide up the world market in proportions yet to be fixed. A much more important question was that of the general production of iron and the manner in which it was to be distributed throughout the world. In any case, the *Excelsior* considered that it will be necessary to limit production in accordance with demand. The whole world was, it added, suffering from over-production resulting from the abnormal demand for iron during the war, which might lead to a catastrophic fall in prices. A delicate point which affected France was that of the export of iron from Lorraine and the Sarre to Germany. The German machinery industry, which made use of French iron, considered that a return should be made in the shape of French purchases of German machinery; that consideration had led the German Government to demand communication of all proposed agreements between representatives of international iron interests. The French Government, it was stated, was also closely watching the negotiations in order to protect France from any possible unemployment. An agreement with regard to the iron industry, our contemporary concluded, would be the first step towards the conclusion of a commercial treaty between France and Germany; the remaining difficulties should be easily surmounted once the stumbling-blocks in the way of an agreement concerning iron had been overcome.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

R. W. WEEKES asks us to announce that he has moved his offices from Maxwell House, Arundel-street, Strand, W.C. 2, to Clutha House, 10, Prince's-street, Westminster, S.W. 1. His new telephone number is Victoria 4007.

WESTON CONCRETE ENGINEERING COMPANY, Ltd., asks us to announce that its registered offices and works are now Metropolitan Steelworks, 78, High-street, West Norwood, S.E. 27, and requests that, in future, all communications should be sent to that address.

ARDROSSAN DOCKYARD, Ltd., is the title of the new company that has taken over from the Ardrossan Dry Dock and Shipbuilding Company, Ltd., the shipyard at Ardrossan, Ayrshire, where shipbuilding has been carried on for over a hundred years. There are eight building berths, and vessels up to 450ft. in length can be built, the whole works covering 31 acres. There is a dry dock 341ft. long by 47ft. wide with a depth of water on sill of 17ft., and a private wet dock.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. COAST—	
Native	21/-
(1) Spanish	18/6
(1) N. African	18/6
N.E. COAST—	
Native	—
Foreign (c.i.f.)	21/3

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) SCOTLAND—		
Hematite	3 17 0	—
No. 1 Foundry	3 19 0 to 4 1 6	
No. 3 Foundry	3 16 6 to 3 19 0	
N.E. COAST—		
Hematite Mixed Nos.	3 17 0	3 17 0
No. 1	3 17 6	3 17 6
Cleveland—		
No. 1	3 12 6	3 13 0
Silicious Iron	3 12 6	3 13 0
No. 3 G.M.B.	3 10 0	3 10 6
No. 4 Foundry	3 9 0	3 9 6
No. 4 Forge	3 8 6	3 9 0
Mottled	3 7 6	3 8 0
White	3 7 6	3 8 0
MIDLANDS—		
(3) Staffs.—		
All-mine (Cold Blast)	10 10 0	—
North Staffs. Forge	3 17 6	—
,, ,, Foundry	4 7 6	—
(3) Northampton—		
Foundry No. 3	3 3 0 to 3 4 6	
,, Forge	2 16 0 to 2 17 0	
(3) Derbyshire—		
No. 3 Foundry	3 6 0 to 3 7 0	
Forge	3 0 0 to 3 2 0	
(3) Lincolnshire—		
No. 3 Foundry	3 8 0	—
No. 4 Forge	3 5 6	—
Basic	3 6 0	—
(4) N.W. COAST— N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 10 0 (a); 4 12 6 (b); 4 17 6 (c)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
SCOTLAND—		
Crown Bars	11 5 0	—
Best	—	—
N.E. COAST—		
Common Bars	11 0 0	—
LANCS.—		
Crown Bars	11 10 0	—
Second Quality Bars	10 5 0	—
Hoops	14 0 0	—
S. YORKS.—		
Crown Bars	12 10 0	—
Best ,,	13 10 0	—
Hoops	14 10 0	—
MIDLANDS—		
Crown Bars	11 0 0 to 12 0 0	
Marked Bars (Staffs.)	14 0 0	—
Nut and Bolt Bars	10 5 0 to 11 0 0	
Gas Tube Strip	12 10 0	—

STEEL.

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) SCOTLAND—		
Boiler Plates	11 0 0	—
Ship Plates, ½in. and up.	7 7 6	—
Sections	6 17 6	—
Steel Sheets, under 3/16in. to ¼in.	9 0 0	—
Sheets (Gal. Cor. 24 B.G.)	—	£17 to £18

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. COAST—		
Ship Plates	7 7 6	—
Angles	7 0 0	—
Boiler Plates	11 10 0	—
Joists	7 0 0	—
Heavy Rails	8 0 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	8 2 6	—
Soft Billets	7 5 0	—
N.W. COAST—		
BARROW—		
Heavy Rails	8 0 0†	—
Light ,,	8 5 0 to 8 10 0	
Billets	7 10 0 to 9 0 0†	
MANCHESTER—		
Bars (Round)	8 0 0 to 8 5 0	
,, (others)	8 0 0 to 8 5 0	
Hoops (Best)	13 5 0	13 0 0
,, (Soft Steel)	10 0 0	9 15 0
Plates	7 12 6	—
,, (Lancs. Boiler)	11 10 0	—
SHEFFIELD—		
Siemens Acid Billets	10 10 0	—
Bessemer Billets	11 5 0	—
Hard Basic	8 12 6	—
Intermediate Basic	8 2 6	—
Soft Basic	8 15 0	-
Hoops	12 0 0	—
Soft Wire Rods	9 10 0	—
MIDLANDS—		
Small Rolled Bars	7 15 0 to 8 0 0	
Billets and Sheet Bars	6 0 0 to 6 2 6	
Sheets (20 W.G.)	11 10 0 to 12 0 0	
Galv. Sheets, f.o.b. L'pool	16 0 0 to 16 5 0	
Angles	7 0 0 to 7 5 0	
Joists	7 0 0 to 7 5 0	
Tees	8 0 0 to 8 5 0	
Bridge and Tank Plates	7 15 0 to 8 0 0	
Boiler Plates	11 0 0 to 11 10 0	

NON-FERROUS METALS.

SWANSEA—	
Tin-plates, I.C., 20 by 14	19/3 to 19/6
Block Tin (cash)	292 5 0
,, (three months)	283 10 0
Copper (cash)	58 10 0
,, (three months)	59 7 6
Spanish Lead (cash)	31 12 6
,, (three months)	31 16 3
Spelter (cash)	33 17 6
,, (three months)	34 2 6
MANCHESTER—	
Copper, Best Selected Ingots	63 10 0
,, Electrolytic	66 10 0
,, Strong Sheets	90 0 0
,, Tubes (Basis Price)	0 1 1
Brass Tubes (Basis Price)	0 1 0
,, Condenser	0 1 2½
Lead, English	33 7 6
,, Foreign	32 10 0
Spelter	34 12 6

FERRO ALLOYS.

(*All prices now nominal.*)

	Per Ton.	Per Unit.
Tungsten Metal Powder	2/1 per lb.	
Ferro Tungsten	1/9½ per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£22 10 0	7/6
,, 6 p.c. to 8 p.c. ,,	£22 0 0	7/3
,, 8 p.c. to 10 p.c. ,,	£20 15 0	6/6
,, Specially Refined		
,, Max. 2 p.c. carbon	£39 0 0	14/-
,, ,, 1 p.c. ,,	£44 10 0	14/6
,, ,, 0·70 p.c. carbon	£55 10 0	17/6
,, ,, carbon free	1/5½ per lb.	
Metallic Chromium	3/3 per lb.	
Ferro Manganese (per ton)	£15 for home, £15 for export	
,, Silicon, 45 p.c. to 50 p.c.	£11 15 0 scale 5/- per unit	
,, ,, 75 p.c.	£20 10 0 scale 6/- per unit	
,, Vanadium	14/6 per lb.	
,, Molybdenum	6/- per lb	
,, Titanium (carbon free)	1/- per lb.	
Nickel (per ton)	£170	
Cobalt	10/- to 11/- per lb.	
Aluminium (per ton)	£120	

FUELS.

SCOTLAND.

	Export.
LANARKSHIRE—	
(f.o.b. Glasgow)—Steam	15/6
,, ,, Ell	15/3
,, ,, Splint	16/6 to 19/9
,, ,, Trebles	15/6
,, ,, Doubles	13/3
,, ,, Singles	12/9
AYRSHIRE—	
(f.o.b. Ports)—Steam	15/6
,, ,, Jewel	16/6
,, ,, Trebles	15/6
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—Steam	12/9 to 15/3
Screened Navigation	21/-
Trebles	15/- to 16/-
Doubles	12/9
Singles	12/6
LOTHIANS—	
(f.o.b. Leith)—Best Steam	14/-
Secondary Steam	13/3
Trebles	14/3
Doubles	13/-
Singles	12/3

ENGLAND.

(8) N.W. COAST—	
Steams	24/-
Household	40/- to 48/-
Coke	26/-
NORTHUMBERLAND—	
Best Steams	16/3 to 17/-
Second Steams	14/- to 14/6
Steam Smalls	8/- to 8/6
Unscreened	13/- to 13/6
Household	20/- to 22/-
DURHAM—	
Best Gas	17/6 to 18/-
Second	14/6 to 15/-
Household	20/- to 22/-
Foundry Coke	18/- to 20/-
SHEFFIELD—	Inland.
Best Hand-picked Branch	31/- to 34/-
Barnsley Best Silkstone	28/- to 30/- —
Derbyshire Best Brights	26/- to 28/- —
,, ,, House	24/- to 25/- —
,, ,, Large Nuts	17/- to 20/- —
,, ,, Small	12/6 to 14/- —
Yorkshire Hards	17/- to 19/6 —
Derbyshire ,,	16/- to 19/- —
Rough Slacks	10/- to 12/6 —
Nutty ,,	7/6 to 9/- —
Smalls	3/6 to 6/- —
Blast-furnace Coke (Inland)*	— —
,, ,, (Export)	f.o.b. 16/- to 17/-

(9) SOUTH WALES.

CARDIFF—	
Steam Coals:	
Best Smokeless Large	23/6 to 24/-
Second ,, ,,	21/6 to 22/6
Best Dry Large	22/- to 24/-
Ordinary Dry Large	19/6 to 20/-
Best Black Vein Large	21/- to 22/-
Western Valley Large	20/- to 20/6
Best Eastern Valley Large	20/- to 20/6
Ordinary ,, ,,	19/- to 20/-
Best Steam Smalls	13/- to 14/-
Ordinary ,,	11/6 to 12/6
Washed Nuts	17/6 to 26/-
No. 3 Rhondda Large	26/6 to 27/-
,, ,, Smalls	15/6 to 16/-
No. 2 ,, Large	19/- to 20/-
,, ,, Through	16/- to 17/-
,, ,, Smalls	10/6 to 11/-
Foundry Coke (export)	40/- to 50/-
Furnace Coke (export)	25/- to 30/-
Patent Fuel	21/- to 22/6
Pitwood (ex ship)	23/6 to 24/-
SWANSEA—	
Anthracite Coals:	
Best Big Vein Large	39/- to 40/-
Seconds	30/- to 32/6
Red Vein	27/- to 29/-
Machine-made Cobbles	50/- to 52/6
Nuts	50/- to 52/6
Beans	40/- to 42/6
Peas	21/- to 24/-
Breaker Duff	6/- to 7/-
Rubbly Culm	9/6 to 10/6
Steam Coals:	
Large	22/- to 23/-
Seconds	20/- to 22/-
Smalls	9/- to 10/-
Cargo Through	16/- to 17/-

(1) Delivered. (2) Net Makers' works. (3) f.o.t. Makers' works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire, and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. * For blast-furnaces only, 17/-, with fluctuations according to analysis; open market, 17/6 to 19/- at ovens. † Latest quotations available. (*a*) Delivered Glasgow. (*b*) Delivered Sheffield. (*c*) Delivered Birmingham.

French Engineering Notes.

(From our Correspondent in Paris.)

Electricity on the Farm.

THE electrical equipment of farms has become a national necessity, because it is feared that, unless something is done to enable agriculturists to make the most of the diminishing supply of labour and to improve rural conditions sufficiently to bring a better class of labour back to the land, the industry runs a serious risk of declining in importance and prosperity. During the agricultural show in Paris last week a special day was set apart for a rural electrification propaganda, and at a conference in the Palais de l'Exposition, the data supplied showed that rural electrification has been making much more progress than is generally surmised. It was stated that one half of the French communes were being supplied with electric current. The main object of this enterprise is to aid the agriculturist, but while there is an unfailing optimism over the final result, it cannot be said that the communications presented to the conference provided evidence of any noteworthy achievement, beyond the application of electric motors to a few classes of farm machines and the encouraging results obtained with electrical cultivation. The success of electrification depends obviously upon the economies which farmers will be able to realise and on their being able by its aid to produce more with a limited supply of labour. So far no one has been able to produce evidence of such economies, but there is no doubt that they can be obtained by a suitable organisation if the price of current is sufficiently low. At first hopes were held out that agriculturists would be favoured with a particularly low price by the creation of a preferential tariff whereby industrial consumers would be made to pay for the farmer, but the cost of distributing current in purely agricultural districts is found to be far higher than had been anticipated, and although the price at which current is supplied to consumers is very much below what it is in most other countries, farmers still complain that it is too high. Nevertheless, for working farm machines the total annual cost is small, and there is no reason why the driving of such machines as thrashers, food preparing machinery, cream separators and the like should not be done electrically when the machines themselves are adapted for running with motors. That was one of the points dealt with at the conference, when it was pointed out that all the machines should be built for certain standard powers and be run at one standard speed. The necessity of fixing upon standard sizes is imposed by the desirability of limiting the powers of electric motors to, say, 1 horse-power, 3 horse-power and 5 horse-power. For the same reason, the shaft speeds of the machines should be standardised so that they can all be used with one type of reduction gear.

Electrical Ploughing.

Of most importance to farmers is the economy of electricity for ploughing. Tillage operations absorb about 80 per cent. of the power used on a farm, and at the present time the agriculturist looks upon electricity as the power which will enable him to till more land and to plough more deeply, for he has learned a great deal of late years about the value of deep ploughing and subsoiling. Steam ploughing has always been employed fairly extensively in the northern departments, especially in the beet districts, and it has had a certain vogue for preparing the vineyards in the south, but the French only accepted steam because there was nothing else available, and the efforts now being made to introduce electric ploughing sets are meeting with enthusiasm. In the department of the Marne such machines are being used in increasing numbers, with satisfactory results, and, in the south, a firm at Carcassonne is supplying electrical equipments of this kind. The heaviest machines are made by the Société Générale Agricole, which offers two types, one of 45-50 horse-power and another of 150-200 horse-power, the latter weighing more than 20 tons. In this vehicle the current is taken direct from the feeder at 5000 volts, instead of employing a separate transformer. The Carcassonne machine weighs only 3 tons, and is anchored by the pull of the cable on a lever which bears on a compressed air cylinder with a base in the form of a jack. There are, of course, no more difficulties in the way of electric ploughing than of steam ploughing, and the only factor affecting the future of electric cultivation is that of economy. Great precautions have to be taken to prevent accidents from the use of high-tension currents; the equipment has to be placed in the charge of skilled hands, and during the conference it was pointed out that the skill of the men running the plant had much to do with its efficiency. Then the maintenance charges of an electrical ploughing installation are high, and the first cost of an electrical equipment is considerable. It is only after taking into account all these factors that it is possible to determine whether electrical cultivation is really economical. So far no reliable data regarding costs are forthcoming, because the conditions of ploughing vary so considerably that it will only be possible to tabulate average costs when much longer experience has been gained. The current consumption may vary widely with the character of the soil and the plant used. With a big 150-200 horse-power machine the consumption was from 12 to 18 kWh per acre with furrows 18in. deep. With a 35 horse-power machine in the South of France 5¾ acres were tilled in a little more than seven hours, with a consumption of 26 kWh per acre. The overhead charges of an electrical ploughing set are so much higher than those of a steam cultivation tackle that convincing figures will have to be forthcoming to prove the superior economy of electricity. Nevertheless, so far as France is concerned, steam ploughing can never become general, because the conditions do not favour it except in particular districts, and the only influence at work in popularising electrical cultivation is that all farmers will eventually have an ample supply of energy brought to them, and the problem now consists in organising local conditions so that agriculturists will be able to arrange their fields in such a way as to favour electrical ploughing with the aid of plants which, it is suggested, should be purchased by a group of farmers in each district. Much also depends upon whether current will always be available at the present low rates.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

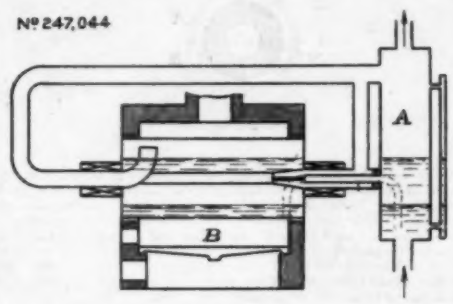
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

STEAM GENERATORS.

247,044. May 5th, 1925.—A ROTARY STEAM GENERATOR, J. V. Blomquist, Stockholm, Sweden.

It is really rather puzzling to follow the claim for novelty in this specification, as it appears to centre round the provision of a separate exterior vessel A for supplying feed water to the tubes of a boiler B, the vessel being subject to the full steam

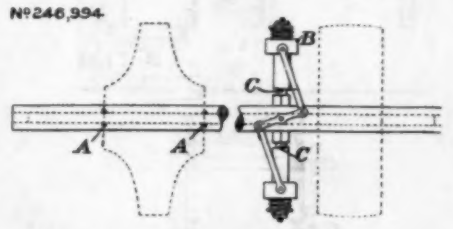


pressure, with a consequence that the feed water will gravitate into the evaporating tubes. It is noteworthy, however, that the claims are made in connection with a boiler of which the steam generating tubes are rotated at a slow speed—not rapidly, as in the case of the inventor's previous boiler—so that the water is not distributed around the whole periphery of the tube by centrifugal action.—*February 11th*, 1926.

TURBINE MACHINERY.

246,994. January 19th, 1925.—GOVERNORS FOR WATER TURBINES, G. C. Oakes, Nowton-court, Bury St. Edmunds, and Njoro, Kenya Colony, British East Africa.

The inventor proposes to govern the speed of water turbines by admitting air at the inlet and thus reducing the velocity of

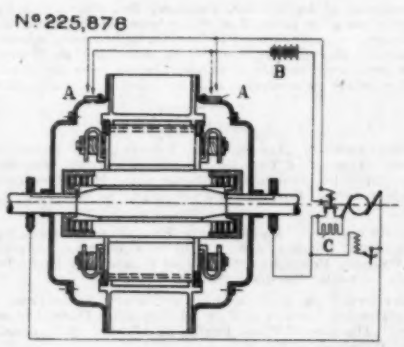


the water passing through the runner. For this purpose the shaft is made hollow and openings are provided near the inlets to the runner, as shown at A A. The governor B is of a simple centrifugal type and controls ports C C, which admit air to the hollow shaft when the speed rises above a predetermined limit.—*February 11th*, 1926.

DYNAMOS AND MOTORS.

225,878. December 6th, 1924.—IMPROVEMENTS IN OR RELATING TO PROTECTIVE DEVICE FOR DYNAMO-ELECTRIC GENERATORS, Siemens-Schuckertwerke Gesellschaft mit beschränkter Haftung, of Siemensstadt, near Berlin, Germany.

According to this invention fluctuations in the pressure in the gaseous or atmospheric cooling medium are utilised to operate

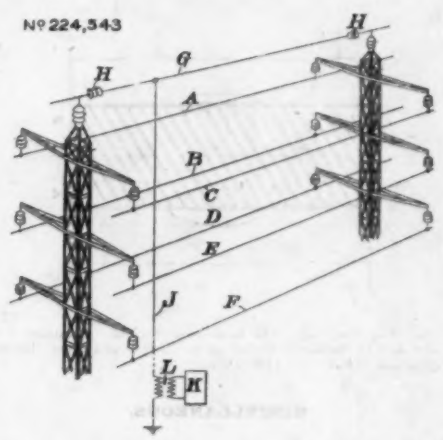


safety devices for switching off the generator and interrupting the excitation in the event of electrical disturbances occurring within the machine. In the event of a sudden defect—for example, an arc at the winding heads—the fluctuation in the pressure of the cooling air causes the valves A to be lifted, thereby closing an auxiliary circuit fed by a battery B, and the short circuit across the resistance C is removed. The resistance C is therefore inserted in the exciting circuit, and the excitation of the generator is reduced.—*February 11th*, 1926.

TELEGRAPHS AND TELEPHONES.

224,543. November 6th, 1924.—IMPROVEMENTS IN HIGH-FREQUENCY ELECTRIC SIGNALLING SYSTEMS, *The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.* 2.

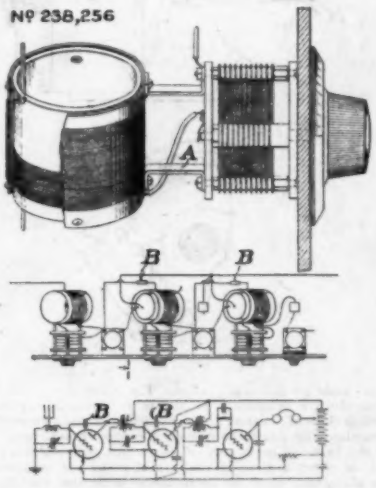
This invention relates more particularly to systems in which high-frequency signalling currents are transmitted over high-potential electrical transmission lines. Many power transmission lines are provided for protective purposes with an earth wire which is supported on the tops of the supporting towers and which is earthed at frequent intervals. According to the invention, a section of this earth wire is employed as a coupling wire by insulating a suitable length from the main portion and impressing the signalling currents upon the insulated section. This does not interfere in any way with the protection afforded by the earth wire as the insulated section will also be connected to earth and the signalling currents may be introduced through



the earth connection. In the drawing a transmission system comprises two three-phase transmission lines made up of conductors A to F inclusive. An earth wire G is supported on the tops of the towers by means of insulators and in accordance with the usual practice this earth wire may be earthed at frequent intervals. The section between the towers is insulated from the remainder of the earth wire by strain insulators H and is connected to earth by a conductor J. High-frequency signalling currents supplied by a transmitter K are impressed upon the insulated section of the earth wire by means of a transformer L, the secondary of which is connected in series with the earth lead J.—*February 8th*, 1926.

238,256. September 1st, 1924.—IMPROVED TUNING APPARATUS FOR THE ELIMINATION OF UNDESIRABLE MAGNETIC COUPLING IN HIGH-FREQUENCY ELECTRIC CIRCUITS, *Hazeltine Corporation, 15, Exchange-place, Jersey City, New Jersey, United States of America.*

The main feature of this invention seems to be that the high-frequency transformers, as used in the Hazeltine receivers, are combined with the tuning condensers, as shown in the upper drawing. By mounting the transformers at the back of the variable condensers by means of short brackets A, the trans-



formers are securely held in position, whilst the extremely short leads that are used between the two units eliminate possible magnetic loops and also reduce possible capacity couplings between stages. As usual, the transformers are set at an angle—as shown in the middle illustration—and neutralising condensers B are connected between the grid terminals of each high-frequency amplyfying valve. This method of neutralising the capacities of the valves is described in British Specifications Nos. 223,181 and 222,895 of April 5th, 1923.—*February 1st*, 1926.

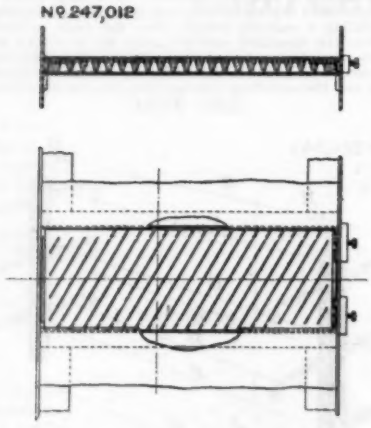
MINING MACHINERY.

247,012. February 10th, 1925.—APPARATUS FOR REMOVING WATER FROM COAL AFTER THE PROCESS OF WASHING, The Butterley Company, Ltd., Derby, and G. F. Wright.

This invention relates to apparatus for removing water from coal after the process of washing, in which the washed coal is pushed along an approximately level platform provided with groups of perforations at intervals. The object of the invention is to increase the efficiency of the apparatus, first by reducing the percentage of fine coal which is carried away with the extracted water, and secondly by reducing the percentage of water left in the coal. In the apparatus as constructed at present with groups of small openings or perforations in the platform at intervals, the size of the perforations cannot be increased with a view to extracting more water from the masses of small coal passing over them, without increasing the proportion of fine coal which finds its way through and is lost. On the other hand, the reduction in the size of the perforations in order to prevent the loss of fine coal results in a reduction in the efficiency of the water-extracting properties of the apparatus, and it would thus appear that the highest possible efficiency had been reached. According to this invention, the apparent impossibility of increasing the efficiency of the apparatus is overcome by employing grids in place of the groups of perforations. Each grid is comprised of a series of preferably straight bars disposed with very narrow parallel slots or spaces between them. The slots

are continuous and extend from one side the platform to the other, but they are not disposed transversely but diagonally, so that the narrow slots or spaces are at an angle to the direction

No 247,012



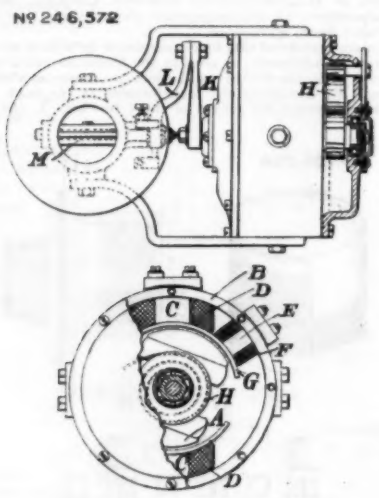
of travel of the coal. The increased efficiency obtained is no doubt due to the form of the water outlets and their diagonal disposition.—*February 11th*, 1926.

MISCELLANEOUS.

246,572. October 28th, 1924.—IMPROVEMENTS IN OR RELATING TO ELECTRICALLY OPERATED GOVERNORS FOR CONTROLLING PRIME MOVERS, Tilling-Stevens Motors, Ltd., and Harold Kenneth Whitehorn, both of Victoria Works, Maidstone, Kent.

The governor described in this specification comprises a rotary armature A mounted within a yoke B, having both shunt and series winding, so arranged that the shunt and series components are respectively applied at different magnetic axes corresponding to, but not necessarily coinciding with, the two extreme governed positions of the throttle. There may be two main poles C opposite to one another and provided with a shunt winding D, which is strengthened by any increase of voltage between the dynamo terminals. In addition, two auxiliary poles E are provided opposite to one another, and preferably having their axes angularly spaced at some 30 deg. to 50 deg.

No 246,572

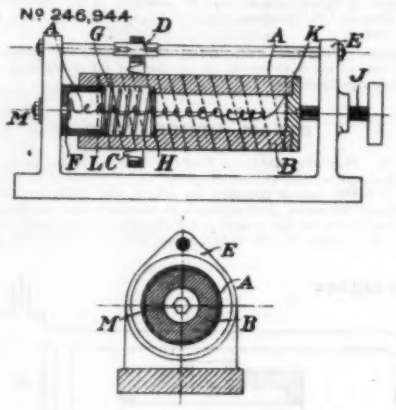


from the axes of the main poles. The auxiliary poles have a series winding F traversed by the main dynamo current or a proportion thereof, so that an increase of the main current tends to strengthen the auxiliary poles. A single shoe G may extend across the faces of each pair of like main and auxiliary poles, so that in effect a zone of maximum resultant magnetic flux travels along the shoe in accordance with the varying ratio between dynamo voltage and dynamo current. A coiled spring H may be employed to balance or steady the action of the device, and will preferably be so set as to help to open the throttle when the latter is nearly closed and a drop in voltage takes place, since in such cases the drop may be such as to prevent the load from increasing to the necessary degree to give immediate relief to the engine by an immediate and sufficient opening of the throttle. The method of connecting the armature to the throttle valve M by lever arms K and L is clearly shown in the upper illustration.—*January 28th*, 1926.

246,944. November 19th, 1924.—IMPROVEMENTS IN AND RELATING TO ELECTRICAL RESISTANCES, Hartley Russell Gwennap Moore, O.B.E., and John Barry Swan, both of H.M.S. Vernon, Portsmouth.

This invention relates to electrical resistances and has for its object a construction which provides a variable resistance with small incremental steps and offers no abrupt change in the self-induction of the resistance when its value is varied. A resistance wire A is wound spirally on a tube of insulating material B, and encircling the tube is a circular contact member C, carried on a slider D, capable of movement parallel to the axis on the tube. The slider is shown mounted on a rod secured to a supporting frame E. One end of the tube is arranged to slide over a cylindrical guide member F, mounted on the supporting frame E, and a spring G is arranged between the guide member F, and an internal shoulder H formed on the tube B. An adjustable screw J passes through a threaded boss, on the supporting frame E, and bears against a cap or closing plate K, on the adjacent end of the tube. One end of the resistance wire is fastened at one end of the insulating tube, as at L, and the wire is then wound spirally on the tube until it reaches the other end. It is then brought through the interior of the tube to a terminal M, which can pass through the guide member F, and through the supporting frame E. The leads can be taken from the terminal M, and from a terminal provided on the slider D, or on the guide rod, which, if used for this purpose, would be a rod of conducting material of low resistance, it being, of course, obvious that whatever arrangement is used, the two leads, one from the terminal M, and the other directly or indirectly from the slider must be properly insulated, one from the other with respect to the supporting frame. The law between the displacement of the slider and the variation of resistance may be any function according to the pitch or variation of pitch of the spiral of resistance wire. In operation the slider contact C is moved along the rod until the approximate position on the insulating tube B is found. The final adjustment is then made by varying the position of the insulating tube B by means of the adjusting screw J bearing on the closed end K, which either

No 246,944



compresses the internal spring G, or allows it to expand, the internal surface of the insulating tube moving over the guide member F. Some of the advantages of such construction are that any law between displacement of the slider and variation of resistance can be followed, that since the circular contact embraces the periphery of the cylinder the slider is able to move from coil to coil without violent changes of self-induction and it also permits changes of resistance equal to a very small fraction of a coil to be made.—*February 11th*, 1926.

247,042. May 1st, 1925.—ROLLER BEARING SLUICE GATES, *Glenfield and Kennedy, Ltd., Kilmarnock.*

This invention is concerned with sluice gates of the Stoney type and relates to the bearing rollers. It is claimed that with the usual arrangement of fixing the rollers in their frames by

No 247,042

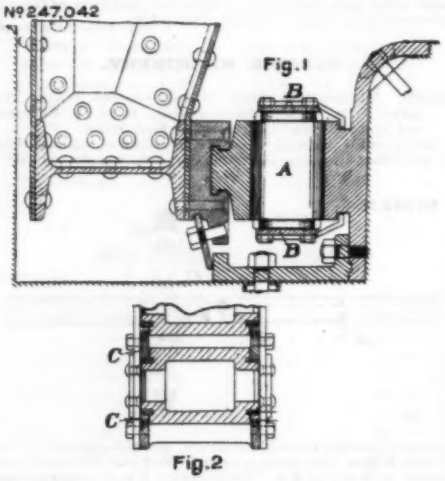


Fig.2

means of axle pins the guidance of the rollers is ineffective. The inventor consequently adopts the construction shown in the illustration. The rollers A are held between side plates B B and are guided by bearing pieces C fixed to the plates, which act in conjunction with slightly reduced diameters at the ends of the rollers as shown in Fig. 2.—*February 11th*, 1926.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

INSTITUTION OF LOCOMOTIVE ENGINEERS: MANCHESTER CENTRE.—College of Technology, Sackville-street, Manchester. Paper, "The Fundamental Principles of the Heat Treatment of Locomotive Steel Forgings and Castings," by Mr. E. F. Lang. 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS.—Storey's-gate, Westminster, London, S.W. 1. Informal meeting. Discussion on "Foundry Practice, with Special Relation to Perlit Iron," introduced by Mr. Summers Hunter. 7 p.m.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—92, Victoria-street, London, S.W. 1. Metropolitan District meeting. Paper, "The Life of Wood Paving as Affected by Expansion," by Mr. J. Garvie. 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street London, S.W. 1. Lecturette, "Metal Aeroplane Construction," by Mr. A. Basil Miller. 7.30 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS.—Engineers' Club, Manchester. Paper, "Hydro-electric Engineering," by Mr. P. W. Seemer. 7.15 p.m.

PHYSICAL SOCIETY OF LONDON.—Imperial College of Science, South Kensington, London, S.W. 7. Papers: "Obliquity Corrections in Radium Estimation," by Mr. I. Backhurst, M.Sc.; "The Viscosity of Water at Low Rates of Flow, determined comparatively by a Method of Thermal Convection," by Professor A. Griffiths and Mr. P. C. Vincent. A demonstration of some simple experiments with thermionic valves will be given by Dr. E. H. Rayner. 5 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. Discourse, "The Radiation from Atomic Nuclei," by Sir Ernest Rutherford. 9 p.m.

SATURDAY, MARCH 27TH.

INSTITUTE OF MARINE ENGINEERS.—85–88, The Minories, Tower Hill, London, E. 1. Juniors' social and dance. 7 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—London Graduates' visit to the Post Office Engineering Research Station, Dollis Hill, N.W. 2. 2.30 p.m.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Shire Hall, Nottingham. East Midland District annual meeting. 2 p.m.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Town Hall, High Wycombe, Bucks. South Midland District meeting. 2 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—Visit to the Canning Town Glassworks, Ltd. 2.30 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle street, London, W. 1. "The Rare Gases of the Atmosphere, IV.," by Sir Ernest Rutherford. 3 p.m.

MONDAY, MARCH 29TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—The Engineers' Club, Coventry-street, London, W. 1. Joint meeting with the Institution of the Rubber Industry. Paper, "Pneumatics for Heavier Loads," by Mr. Colin Macbeth. 8 p.m.

RAILWAY CLUB.—65, Belgrave-road, London, S.W. 1. Paper, "Electricity in Railway Operations," by Mr. W. J. Mitchelhill. 7.30 p.m.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, London, W.C. 2. Cantor Lecture, "Thermometry, III.," by Mr. W. F. Higgins. 8 p.m.

TUESDAY, MARCH 30TH.

ENGINEERS' CLUB.—Albert-square, Manchester. Annual general meeting. 1.45 p.m.

ILLUMINATING ENGINEERING SOCIETY.—E.L.M.A. Lighting Service Bureau, 15, Savoy-street, Strand, London, W.C. 2. Discussion on "Stage Lighting," opened by Mr. H. Lester Groom. 7 p.m.

INSTITUTE OF MARINE ENGINEERS.—85–88, The Minories, Tower Hill, London, E. 1. "Some Marine Researches and Our Sea Fisheries," by Mr. E. Ford. 6.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Broadgate Café, Coventry. Paper, "Developments in Motor Cycle Design," by Mr. J. R. Harnott. 7.15 p.m.

WEDNESDAY, MARCH 31ST.

NEWCOMEN SOCIETY.—Prince Henry's Room, 17, Fleet-street, London, E.C. 4. Papers, "Fathers of the Machine Cotton Industry," by Mr. F. Nasmith; "Some Unusual American Spinning Wheels," by Mr. Serge Daniloff; "Two American Textile Pioneers," by Mr. R. E. Naumburg. 5.30 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS: GRADUATES' SECTION.—Bolbec Hall, Newcastle-upon-Tyne. Address on "Nomograms," by Dr. E. V. Telfer. 7.15 p.m.

WEDNESDAY, APRIL 7TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Cavendish Café, Cornmarket, Derby. Derby Graduates' meeting. Paper, "Problems of the High-speed Optical Indicator," by Mr. A. A. Rubbra. 7.30 p.m.

THURSDAY, APRIL 8TH.

ROYAL AERONAUTICAL SOCIETY.—Royal Society of Arts, 18, John-street, Adelphi, London, W.C. 2. Paper, "A 35,000 Miles' Flight," by Marchesse De Pinedo. 6.30 p.m.

FRIDAY, APRIL 9TH.

DIESEL ENGINE USERS' ASSOCIATION.—Caxton Hall, Westminster, London, S.W. 1. Paper, "Industrial Tests on Internal Combustion Engines," by Mr. W. A. Tookey. 3.30 p.m.

INSTITUTE OF MARINE ENGINEERS.—85–88, The Minories, Tower Hill, London, E. 1. Annual meeting. 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. Paper, "Modern Methods of Cast Iron Pipe Manufacture," by Mr. T. E. Dimbleby. 7.30 p.m.

MONDAY, APRIL 12TH.

INSTITUTION OF STRUCTURAL ENGINEERS.—Piccadilly Hotel, London, W. 1. Annual dinner. 7 for 7.30 p.m.

WEDNESDAY, APRIL 14TH.

INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, London, W.C. 2. Wireless Section meeting. "The Rugby Radio Station of the British Post Office," by Mr. E. H. Shaughnessy. 6 p.m.

CONTRACTS.

FRANK HOW AND CO., Ltd., of Stratford, London, E. 15, have received a large contract for the supply of lubricating oils to the Egyptian State Railways.

THE STURTEVANT ENGINEERING COMPANY, Ltd., has received an order from Australia for three of its largest grinding units for the manufacture of fertilisers.

JAMES CARMICHAEL, Ltd., has received from the London Underground Railways an order for the tiling of the platforms, escalator chambers and passages at Charing Cross, Waterloo, and Kennington stations.

RICHARD GARRETT AND SONS, Ltd., of Aldwych House, Aldwych, London, W.C. 2, and Leiston, have received from the Glasgow Corporation Cleansing Department an order to supply thirty-six of their low-loading-line type electric vehicles for refuse collection in that city.

THE MIRRLEES WATSON COMPANY, Ltd., of Glasgow, has received from Michael Nairn and Co., Ltd., of Kirkcaldy, an order for a complete system of evaporating and de-aerating plant, including heaters and pumps. The de-aerating plant will have a capacity of 72,000 lb. of feed water per hour, while the evaporator, which will produce 10 per cent. feed make-up, will consist of a twin evaporator with two vessels delivering into a common separator.

W. H. ALLEN, SONS AND CO., Ltd., of Bedford, have received from the Ministry of Public Works for Egypt the contract for a new sewage pumping station for Cairo. The main plant will consist of three 550 brake horse-power and one 330 brake horse-power sewage pumping units driven by Diesel engines through speed increasing gear; and the auxiliary plant will include three 30-kilowatt hot-bulb-engine-driven generators, workshop equipment and measuring apparatus.

YARROW AND CO. (1922), Ltd., of Scotstoun, Glasgow, have recently received a further order for the latest type of Yarrow patented water-tube boilers, land type, for the County of London Electric Supply Company's station at Barking. The same firm has also recently received orders for Yarrow boilers for Portsmouth Dockyard; for Michael Nairn and Co., Ltd.; for the City of London Electric Light Company, Bankside; and for the London Electric Supply Corporation, Ltd., Deptford. It has also on hand an order for two high-pressure Yarrow marine boilers of 550 lb. pressure.